Department of Natural Resources
MARYLAND GEOLOGICAL SURVEY
Emery T. Cleaves, Director

COASTAL AND ESTUARINE GEOLOGY
OPEN FILE REPORT NO. 16

NON-ENERGY RESOURCES AND SHALLOW GEOLOGICAL FRAMEWORK OF THE INNER CONTINENTAL MARGIN OFF OCEAN CITY, MARYLAND

by
Darlene V. Wells

submitted to
U.S. Department of the Interior
Minerals Management Service
Continental Margins Program
and
Bureau of Economic Geology
The University of Texas at Austin

in fulfillment
of Contract #14-35-0001-30497

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ABSTRACT

As part of the seventh year of the Minerals Management Service —Association of American State Geologists Continental Margin Program, the Maryland Geological Survey examined over 300 kilometers of high resolution seismic profile records and lithological logs and textural data from 162 vibracores to further delineate the shallow geologic framework of Maryland's inner continental shelf.. The seismic profiles and vibracores were originally collected by the U.S. Army Corps of Engineers (COE) to locate and assess beach fill borrow areas for the Ocean City Beach Replenishment Project.

The textural data from sediment samples taken from the vibracores show that the shallow shelf sediments consist primarily of medium to fine sand. Gravel is not a major component. Sediments become coarser in the northerly and offshore direction.

Vibracores penetrated at least two distinct depositional units in addition to modern shoal sands. The oldest unit penetrated is Pleistocene in age, interpreted to be equivalent to oxygen-isotope stage 5 deposits (~128 - 80 ka). This Pleistocene unit is heterogeneous in texture, ranging from sequences of interbedded, green to gray, muddy sands to gravelly sands. This unit extends throughout the study area and is exposed along the sea floor in the inter-shoal trough areas.

Vibracores also penetrated a broad, shallow paleochannel feature that cuts into the underlying Pleistocene unit and extends under a shore-attached shoal within the shoreface zone. The associated fill deposits contained peat that yielded a radiocarbon date of 5,570±70 yr. B.P. The geometry of shallow paleochannel feature suggests that it is an extension of Roy Creek which drains into Assawoman Bay. Reconstruction of the paleodrainage off Ocean City suggests that the paleo-interfluve corresponding to the Wisconsin drainage divide separating Delaware River system from the St. Martin River system, and perhaps the Susquehanna River system, is located along the Maryland/Delaware state line.

Of the three depositional units sampled within the study area, modern shoal deposits represent the most viable sand source for beach fill. The quality and quantity of shoal sand vary depending on whether the shoal is detached or shore-attached. Detached shoals generally contain larger volumes of coarser sand as opposed to the shore-attached shoals.

The shore-attached shoals within the study area contain very limited volumes of sand suitable for beach fill. These shoals were eliminated by the COE as borrow areas for the Ocean City Beach Replenishment project. Three detached shoals (shoal 2, 3, and 9) were found to contain sufficient volumes of suitable sand and, thus, were selected as potential borrow areas.

Two of these shoals were recently dredged for beach fill for the Ocean City Beach Replenishment Project. Over 7 million cubic meters of sand were excavated from shoals 2 and 3, essentially removing large portions of the shoals themselves and exhausting the borrow areas of suitable sand. The third detached shoal (shoal 9) contains approximately 5 million cubic meters of suitable sand. This shoal will be dredged for beach fill for maintenance replenishment at Ocean City.

INTRODUCTION

In the mid-1980's, the State of Maryland, in cooperation with the U.S. Army Corps of Engineers (COE), initiated an ambitious project to rebuild 12 kilometers of beach along Ocean City, Maryland. The beach replenishment project was implemented in two phases. Phase I, funded by state and local governments, established an enhanced recreational beach. This phase was completed in Fall, 1988, during which 1.73 million cubic meters of sand were placed on 13.4 kilometers of beach. Phase II, funding of which was shared among federal, state and local governments, involved the construction of the dune system and further widening of the beach, and was completed in Fall, 1991. Over 2.7 million cubic meters of sand were placed on the beach during Phase II. Since the completion of Phase II, an additional 1.2 million cubic meters of sand have been placed on the beach to maintain the project and to mitigate storm damage.

To identify areas containing suitable beach fill, the COE conducted a series of geophysical surveys and collected sedimentological data on and around nine shoal areas within 5 kilometers offshore of Ocean City (Figure 1). Over 300 kilometers of seismic reflection profiles were obtained in 1986. Between 1986 and 1989, the COE collected 162 vibracores to obtain textural data for the potential borrow areas. The COE's primary objective during this survey was to delineate the boundaries (*i.e.*, lateral extent and thickness) of sand deposits suitable for beach fill at Ocean City. Although there was some attempt to use the seismic records to identify the lower boundary of the shoal structures, the geophysical data were not analyzed in terms of regional or local stratigraphy. The vibracores were examined and gross lithologies were noted with the primary focus on sandy sediments. Sections of cores that were either below the project limits (below -15 meters National Geodetic Vertical Datum of 1929 (NGVD), (1977 adjusted) or contained predominately fine grained sediment were not opened and described and analyzed for texture. Furthermore, the vibracores were not collected at the same time but in stages related to the assessment of borrow areas prior to each project phase. Consequently, the data from the cores were not published in a single source but were presented in separate documents (U.S. Army Corps of Engineers, 1988, 1989a, 1989b; Anders and Hansen, 1990). Some of the data were never published.

The goal of the seventh year Minerals Management Service cooperative was to systematically review and examine the data collected by COE for the Ocean City Beach Replenishment Project. The objectives of this study were:

1) To further delineate the shallow stratigraphic sequence of the inner continental shelf adjacent to Ocean City, relating the sequence to the geologic framework developed by Toscano *et al.* (1989);
2) To analyze and map textural trends of the sediment to evaluate potential sources of sand and gravel within the study area; and
3) To organize and compile all data into a usable database for further study and future reference.

This report describes and interprets the geophysical and sedimentological data collected by COE for the Ocean City project.

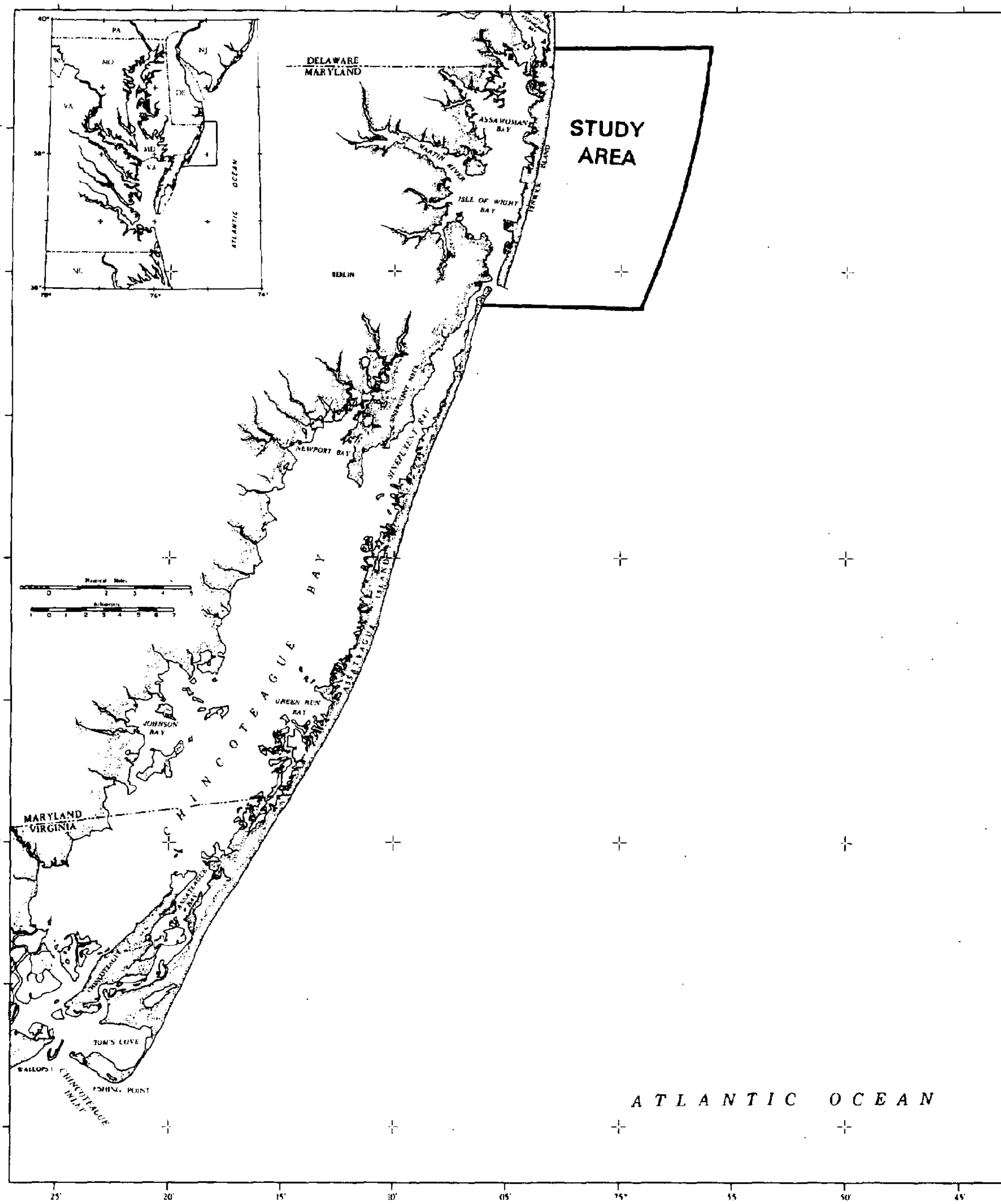


Figure 1. Study area.

ACKNOWLEDGEMENTS

This study was support by the U.S. Minerals Management Service and the Association of American State Geologists cooperative Continental Margin Program, and the Maryland Department of Natural Resources. The vibracores collected for Phase II (Federal Project), original core logs and textural statistics were made available by the Baltimore District of U.S. Army Corps of Engineers. David Blough provided assistance in the xeroradiography, splitting and examining the vibracores, and digitizing over 100 kilometers of seismic profile records. Margarite Carruthers assisted in preliminary review and compilation of lithological descriptions and textural statistics and conducted grain size analyses. Robert Conkwright expertly digitized the detailed bathymetry and the base map for the study area and, with the help of James Lowry, produced many of the figures included in this report. The author extends special thanks to Fred Anders and Mark Hansen of the Coastal Engineering Research Center (CERC), and Jim Snyder of Baltimore District of the U.S. Army Corps of Engineers, for their general assistance and for providing some of the data used in this report. The author is especially grateful to Randall Kerhin and Dr. James Hill for their suggestions and comments regarding this report.

PREVIOUS STUDIES

There have been numerous studies investigating various aspects of the stratigraphy and morphological character of the Mid-Atlantic inner continental shelf. The origin and morphological characteristics of linear shoals (also referred to as ridge and swale topography) were the subject of several investigations. Duane *et al.* (1972), Field (1976; 1979), and Swift and Field (1981) examined the orientation, distributions, and morphologies of linear shoal fields on the Atlantic inner shelf. Based on geophysical, sedimentological and hydraulic data, they concluded that shore-attached shoals form in response to nearshore storm generated currents and eventually become detached as a result of sea level rise. Detached shoals continue to respond to the modern shelf hydraulic regime. McBride and Moslow (1991), using a computer mapping system, correlated the distribution of shore-attached and detached shoals with locations of historical and active inlets along the U.S. Atlantic coast. They found a genetic relationship between shore-attached shoals and certain inlets and concluded that these shoals initially formed from ebb tidal deltas associated with inlets.

Other studies utilized high resolution seismic surveys and cores to document lithostratigraphic relationships and reconstruct paleodrainage. Shideler *et al.*, 1972; 1984, investigated late Quaternary stratigraphy of Virginia inner continental shelf and documented three depositional units separated by two prominent unconformities. The upper unit, C, was identified as Quaternary deposits and described as massive greenish-gray mud with thin laminae of fine sand overlying coarser-grained sediments. A prominent seismic horizon (R2), lying between -17 and -49 meters MSL, marked the lower boundary of the C unit. Modern shelf shoal deposits directly overlay the Unit C deposits.

Three paleochannels, representing successive generations of the Susquehanna River, were identified beneath the Virginia portion the Delmarva Peninsula (Colman *et al.*, 1988, 1990; Colman and Hobbs, 1987). The paleochannels were incised in progressively southern locations as a result of the southward progradation of the tip of the Delmarva Peninsula.

Field (1976; 1980) was one of the first to investigate the shallow sedimentary record of Maryland and Delaware inner shelf and to identify several major seismic reflectors and depositional units. Based on vibracore lithologies, Field described widespread muddy sediments within his A unit, which he designated as Holocene in age based on one radiocarbon date.

Similar geophysical studies were conducted off Delaware's coast, during which Holocene paralic deposits and pre-Holocene erosional surface were identified and characterized (Sheridan *et al.*, 1974; Belknap and Kraft, 1984). The pre-Holocene erosional surface, ranging from -12 to -55 meters in depth, was mapped. The surface defines a dendritic system of tributaries draining into the ancestral Delaware River (Belknap and Kraft, 1984). In depths of less than 37 meters, the erosional surface truncates Pleistocene sediments of variable lithology, including oxidized sand and gravel and desiccated clay. The approximate age of the uppermost unit of the Pleistocene sediments, (Bethany Unit Q_{P5}) was estimated to be 80-100 ka based on amino acid racemization data and correlated to the Sinepuxent and Omar Formations (Demarest *et al.*, 1981; McDonald, 1981). Overlying the basal erosional surface are leading edge Holocene sediments (lagoonal and estuarine mud) of varying thicknesses, ranging from 0 to over 40 meters.

As part of the first four years of the Minerals Management Service Continental Margin Program, the Maryland Geological Survey conducted an integrated study investigating the shallow stratigraphy of the inner shelf off Assateague Island and developed the Quaternary geologic framework for the Maryland inner continental shelf (Kerhin, 1989; Kerhin and Williams, 1987; Toscano *et al.*, 1989; Toscano and Kerhin, 1990; Toscano and York, 1992). The framework model provides the basis for much of the interpretation presented in this report and, therefore, is discussed in detail here.

Based on data from high resolution seismic surveys and vibracores, four significant reflectors and five distinct stratigraphic units were identified on the inner shelf off Assateague Island (Figure 2). The reflectors and stratigraphic units were assigned ages based on amino acid racemization and ostracode assemblage data, and correlations to onshore units (Figure 3). Age assignments are referenced to stages of the oxygen-isotopic record which reflect former glacial-interglacial oscillations (Shackleton and Opdyke, 1976).

A most prominent and persistent reflector (M1) was identified between -21 meters to -36 meters MSL and mapped. The M1 reflector is correlated to the Tertiary-Quaternary unconformity onshore. The M1 reflector is most recognizable in the seismic records as it truncates high to low angle clinoforms and chaotic channels that are characteristic of the upper most portion of the Tertiary unit (T1). The Q1/Q2 depositional unit immediately overlies the M1 reflector and is characterized by parallel to subparallel internal reflectors. A persistent, but weaker reflector, M2, that separates the Q1 from the Q2, runs parallel to and approximately 5 to 6 meters above the M1 reflector. The M2 reflector is interpreted to represent an erosional surface formed during oxygen-isotope (glacial) stage 6 (~190 - 130 ka). Sediments from vibracores that penetrated the upper portion of the Q1 unit were sands and gravelly sands containing shells. Based on amino acid racemization data from the genus *Mulinia*, the Q1 unit is interpreted to be equivalent to oxygen-isotope stage 7 (250 -200 ka) or older. The overlying Q2 unit consists primarily of

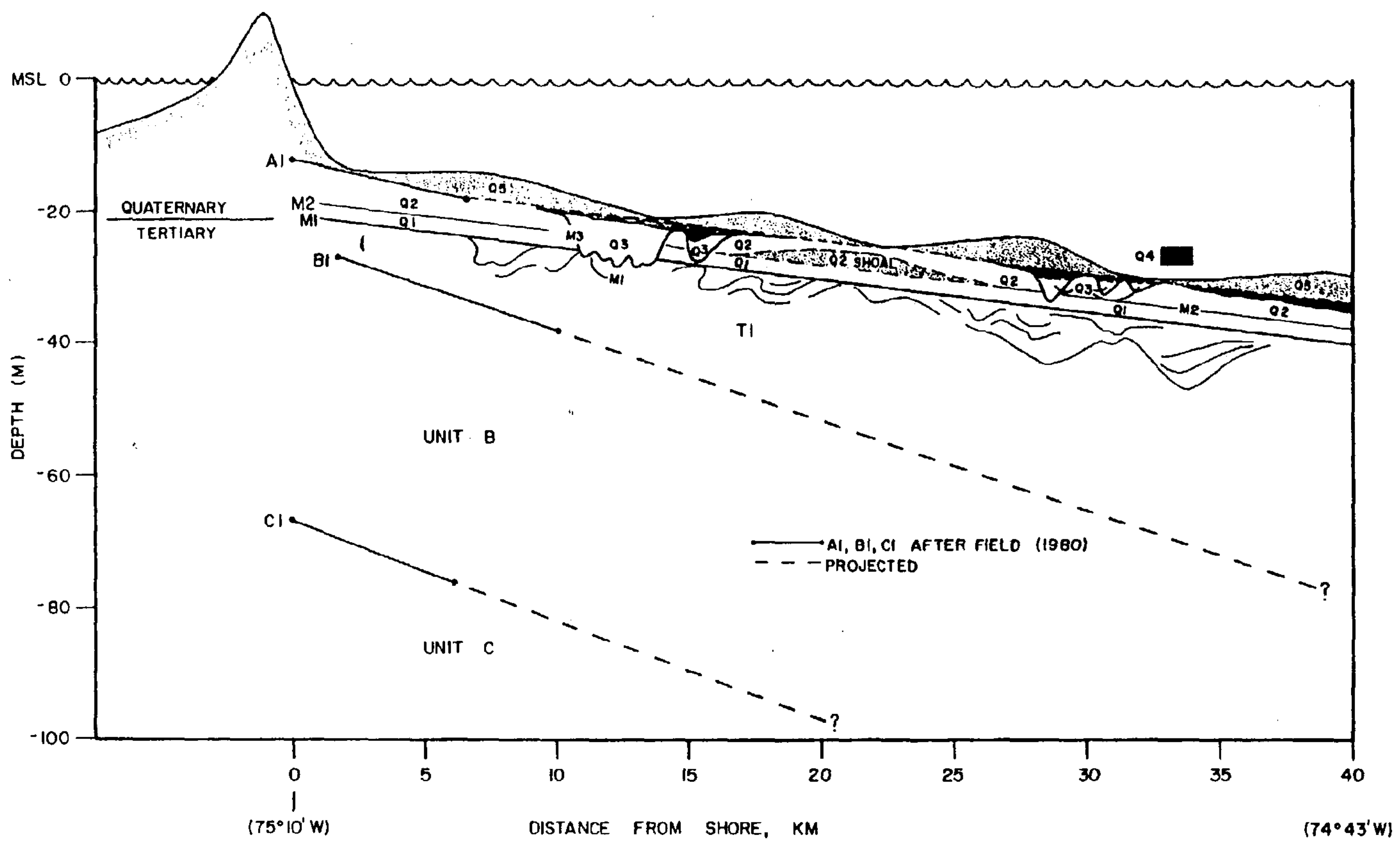


Figure 2. Maryland's inner continental shelf stratigraphy (from Toscano *et al.*, 1989).

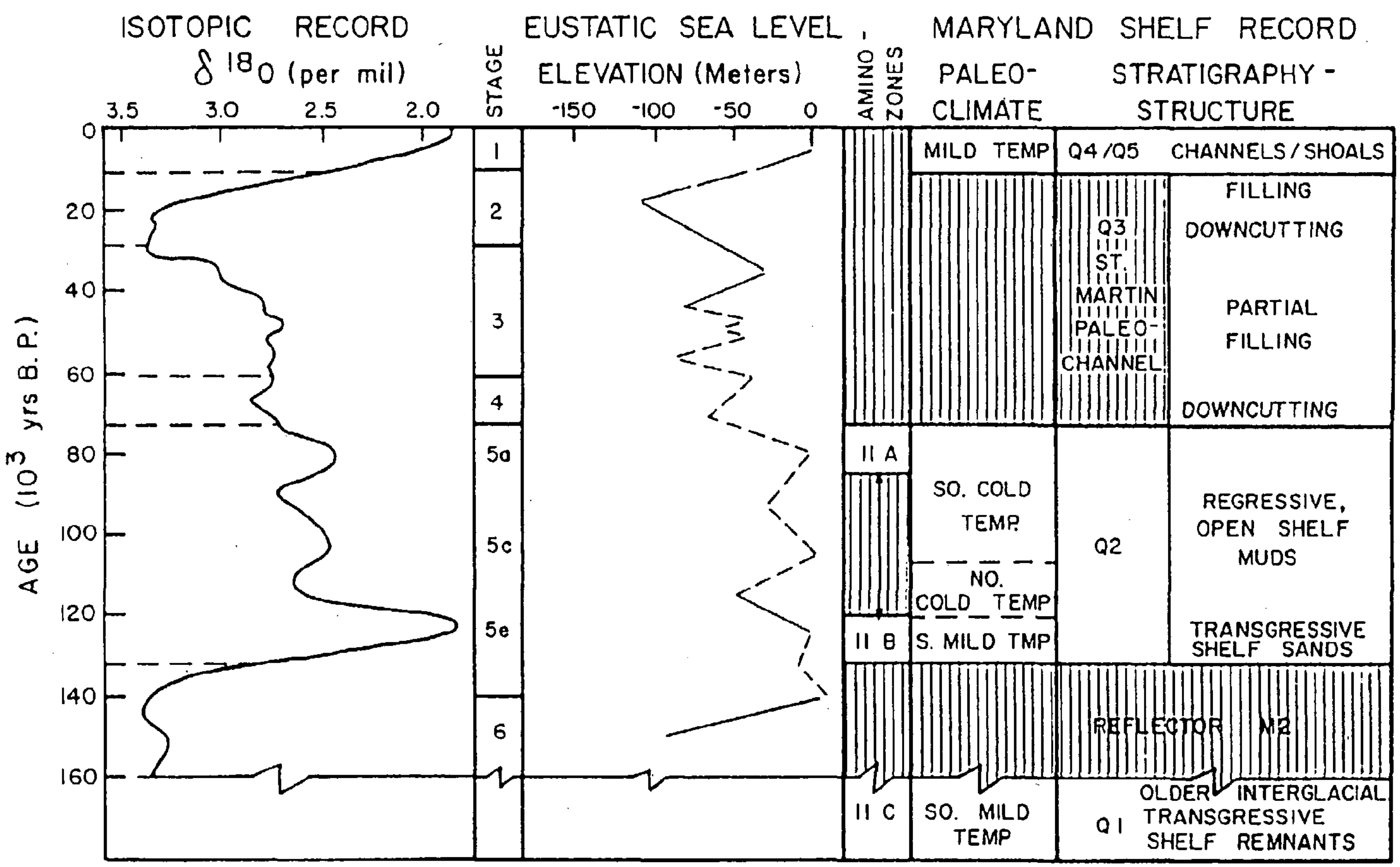


Figure 3. Age assignments of Maryland shelf lithologic units and erosional surfaces to appropriate time frames based on amino acid racemization data, correlations to onshore dated units, and the context of global glacioeustatic ice volume and sea level records (from Toscano *et al.*, 1989).

dewatered, fossiliferous mud. A basal Q2 sand layer was preserved in several vibracores. One core (20-1430) penetrated a thick sequence of sand that was below Q2 muds but stratigraphically above the M2 horizon. This sand unit is interpreted to be a transgressive sand body analogous to the modern shelf shoals.

Amino acid racemization data from the genus *Mulinia* indicate that the Q2 unit was deposited during the oxygen-isotope stage 5 (~128-75 ka). Within the Q2 unit, ostracode assemblage data identify four paleoclimatic zones, enabling correlation of the zones to sea level fluctuations in oxygen-isotope stage 5 (Toscano and York, 1992). Ostracode zone 1, contained within the basal Q2 sands, is correlated to substage 5e (~128-120 ka) (Figure 3). The basal Q2 sands are interpreted to be peak transgressive shelf deposits of early stage 5. Ostracode zones 2 through 4 are contained within the Q2 mud unit and are correlated to substage 5d (~120-110 ka), 5c (~110-103 ka), and 5a (~90-75 ka), respectively (Toscano *et al.*, 1989; Toscano and York, 1992; Toscano, 1992). The Q2 mud unit, interpreted to be open-shelf muds deposited during the 50 ka-long period (oxygen-isotope stage 5) of slightly depressed sea levels, represents a depositional environment unique to the Maryland shelf (Toscano, 1992).

Unit Q3 represents fluvial fill deposits of an ancestral St. Martin tributary system (Figure 4). The tributary system was incised into the shelf during the Wisconsin glaciation (oxygen-isotope stages 4 through 2; ~74 -17 ka). The fluvial erosional surface defining St. Martin paleochannel is represented by the M3 reflector. There are no deposits equivalent to oxygen-isotope stages 4, 3, and 2 on the Maryland inner shelf.

Both Q4 and Q5 depositional units are Holocene in age. The Q4 unit is interpreted to be transgressive leading edge deposits (lagoonal/swamp sediments) and overlaps Q3 and Q2 depositional units. Unit Q5 represents modern shelf shoal deposits.

STUDY AREA

The study area presented here is limited to the area investigated by COE for borrow material to be used in the Ocean City Beach Replenishment Project. The study area is within Maryland's Atlantic nearshore between Ocean City Inlet and the Delaware state line. The eastern boundary of the study area is 3 nautical miles (5.5 km) from shore (Figure 1). Within the study area, two groups of linear shoals are present: shore-attached shoals (or ridges) defined by, but landward of, the -10 m contour, and nearshore shoals out to the -16 meter contour (Field, 1980). The COE focused on both groups of shoals in their search for suitable sand to be placed on the beach at Ocean City. The location of the nine shoals considered as potential borrow sites are indicated in Figure 5. Shoal 1 is the crescent shaped ebb tidal delta located seaward of Ocean City Inlet. Shoals 4, 5, 6, and 7 are shore-attached shoals. Shoals 2, 3, 8, and 9 are detached nearshore shoals.

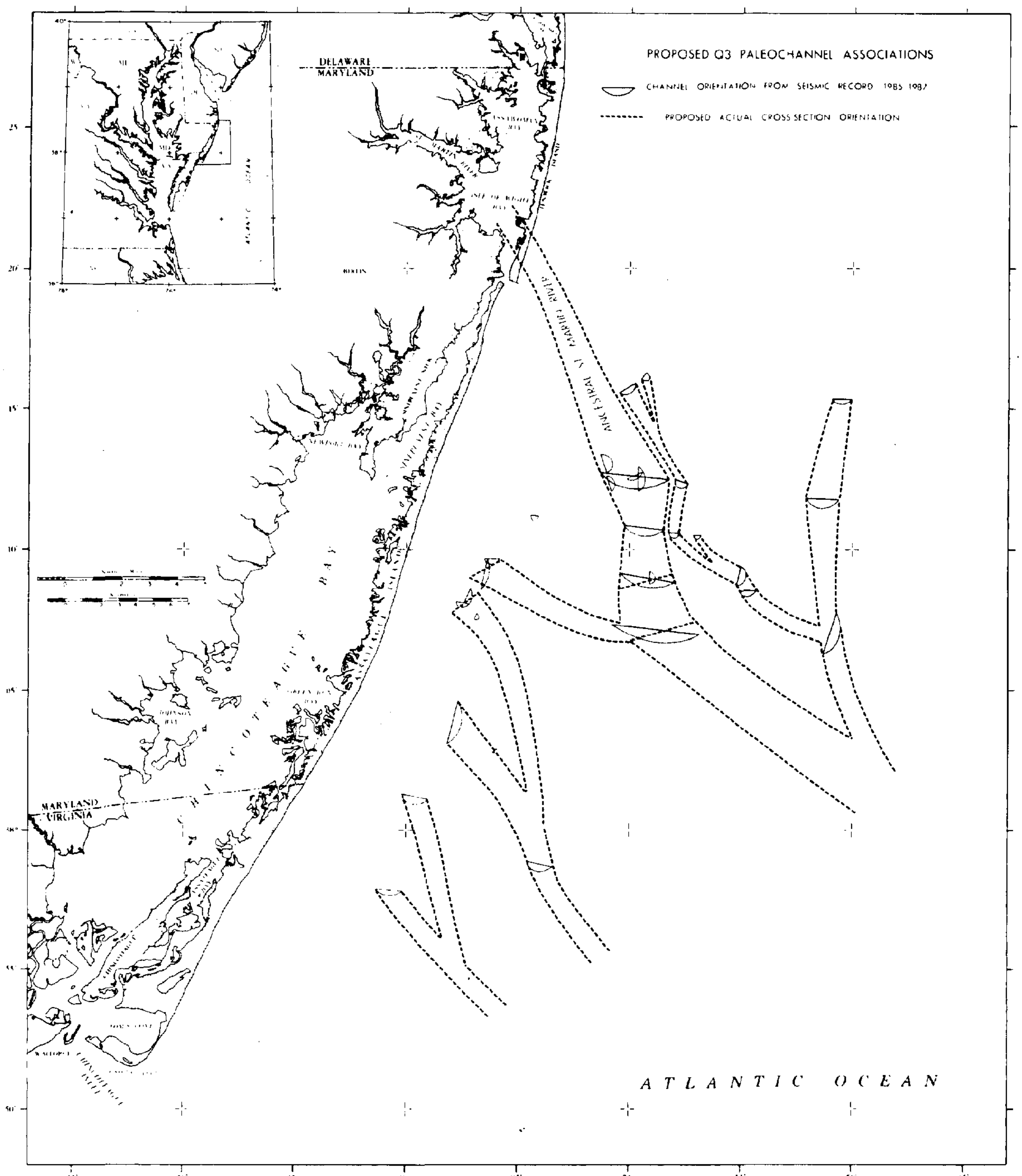


Figure 4. Reconstruction of paleo-drainage system defined by the M3-M1 channels (from Toscano *et al.*, 1989).

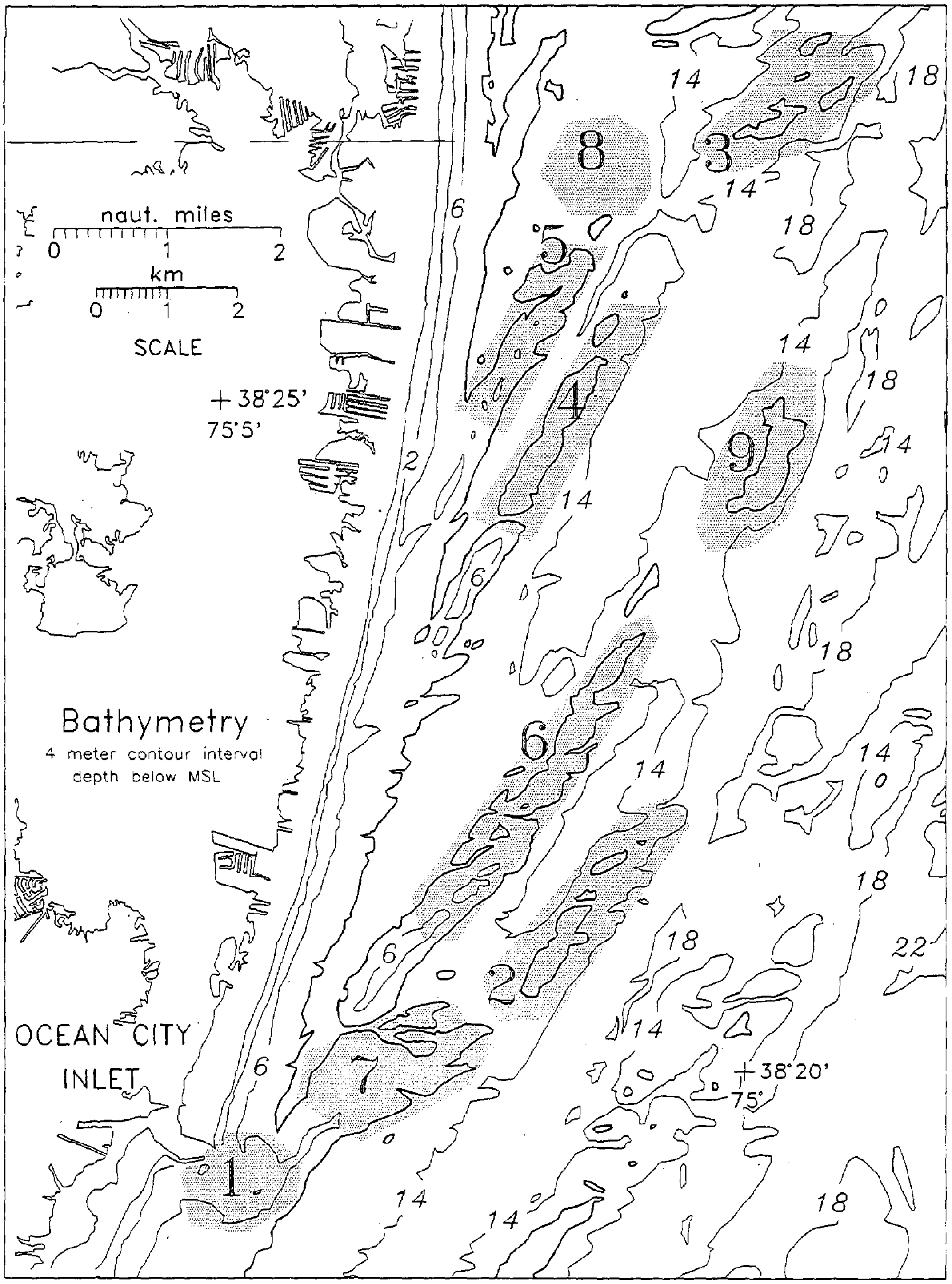


Figure 5. Bathymetry of study area. The nine study shoals are indicated by shading and are numbered.

METHODS

SEISMIC SURVEYS

Seismic profile surveys were collected in 1986 by the COE Coastal Engineering Research Center (CERC) in cooperation with the Maryland Department of Natural Resources. An ORE subbottom profiler operating at a frequency of 3.5 kHz was used. Transects for the seismic surveys followed a grid pattern over each of the potential borrow sites. Grid lines perpendicular to the shoal axis were spaced 175 m apart. Tie lines were spaced at larger intervals parallel to the axis of the shoals (Figure 6). Loran C and Mini-Ranger systems were used for navigation.

High resolution seismic records collected in 1985 and 1987 by the Maryland Geological Survey (MGS) in cooperation with U.S. Geological Survey were also re-examined in order to confirm or facilitate the interpretation of the CERC seismic records. MGS seismic data include both 3.5 kHz and Geopulse (200 joules) records. Prominent reflectors, specifically the M1 and M2, were identified in MGS line 16 (see Toscano *et al.*, 1989) and traced northward along MGS lines 52, 53, 54, 35, and 1 (Figure 6) to where they intersected the COE seismic lines. The M1 reflector was traced along the geopulse records whereas the 3.5 kHz records were used to track the M2 reflector.

VIBRACORING

The 162 vibracores used in this study were collected between 1986 and 1989 by the COE to assess borrow material for the Ocean City project. Table I lists the vibracores according to time of collection and shoal areas. The vibracores collected in 1986 and 1987 were used to assess borrow areas for Phase I and II respectively. The vibracores collected in 1989 were used for the assessment of future borrow areas for periodic maintenance of the Ocean City beach over the projected lifetime (Phase III—Future Maintenance). Figure 7 shows the location of the 162 vibracores.

The locations for the 57 vibracores collected in 1986 by the Coastal Engineering Research Center (CERC) prior to Phase I, were based on bathymetry and seismic data (Anders and Hansen, 1990). The Phase I cores were collected using an Alpine vibracorer fitted with 20 ft plastic core liners 3.87 inches in diameter. The Phase I cores were cut into one meter sections to facilitate handling.

The remaining 105 vibracores (Phase II and Phase III) were collected by Ocean Surveys, Inc. under contract with the Baltimore District COE. An OSI Model 1500 Vibracorer fitted with 3.5 inch ID Lexan core liners was used to collect the vibracores. Once collected, Phase II and III cores were cut into 1.5 meter sections for easier handling. Locations for the 105 vibracores were based on a 1000 by 1000-ft grid covering the selected borrow sites (Jim Snyder, Baltimore District, U.S. Army Corps of Engineers, oral com.). Depths at which vibracores were collected are referenced to National Geodetic Vertical Datum of 1929 (NGVD), 1977 adjusted. In this report, NGVD is used in lieu of Mean Sea Level (MSL).

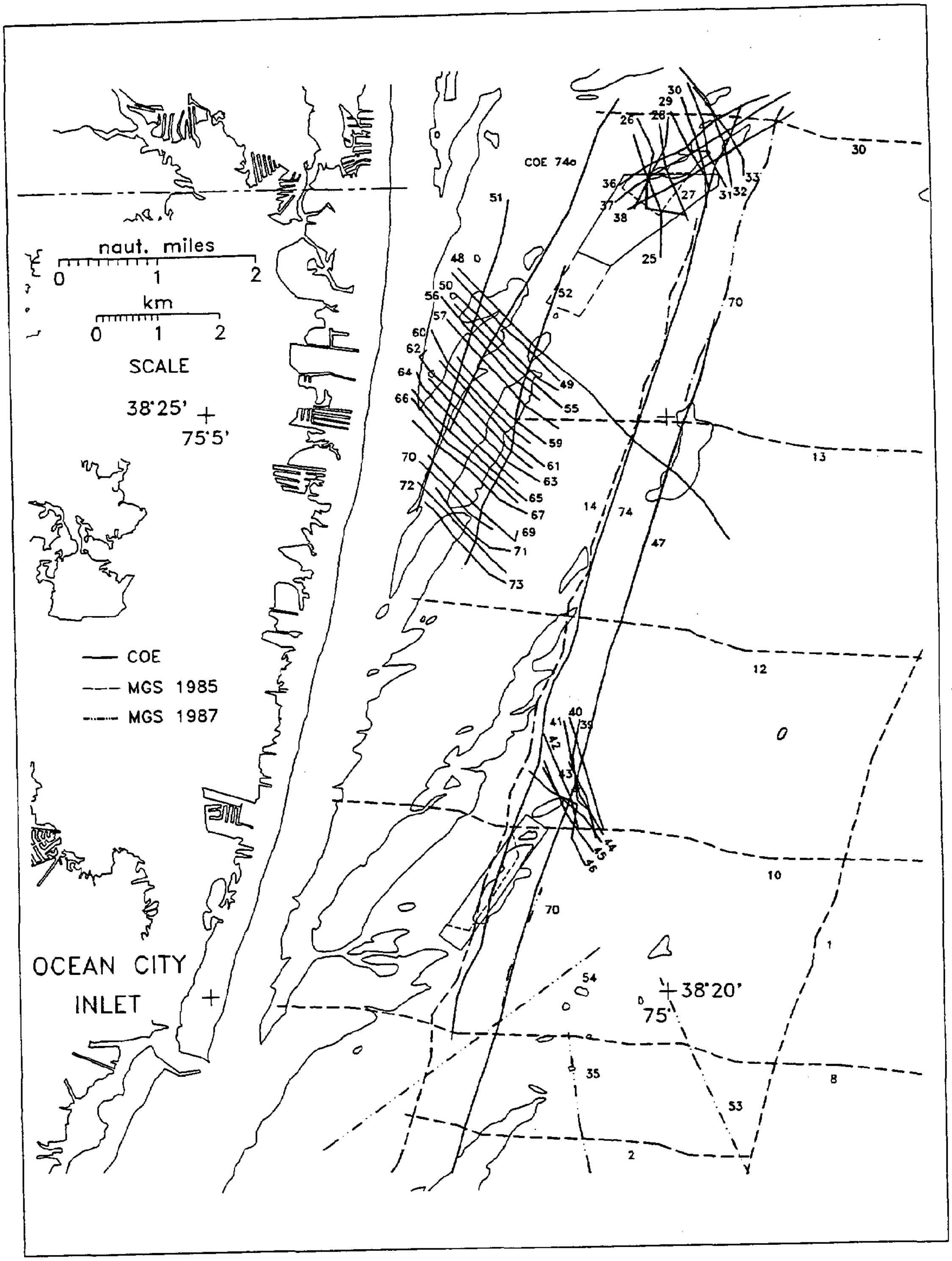


Figure 6. Track lines for high resolution seismic profiles collected by the U.S. Army Corps of Engineers (COE) in 1986 (solid lines). Also shown are selected track lines of seismic profiles collected by the Maryland Geological Survey in 1985 (dashed lines) and in 1987 (dash-dot lines). The 10 meter isobath is indicated for reference.

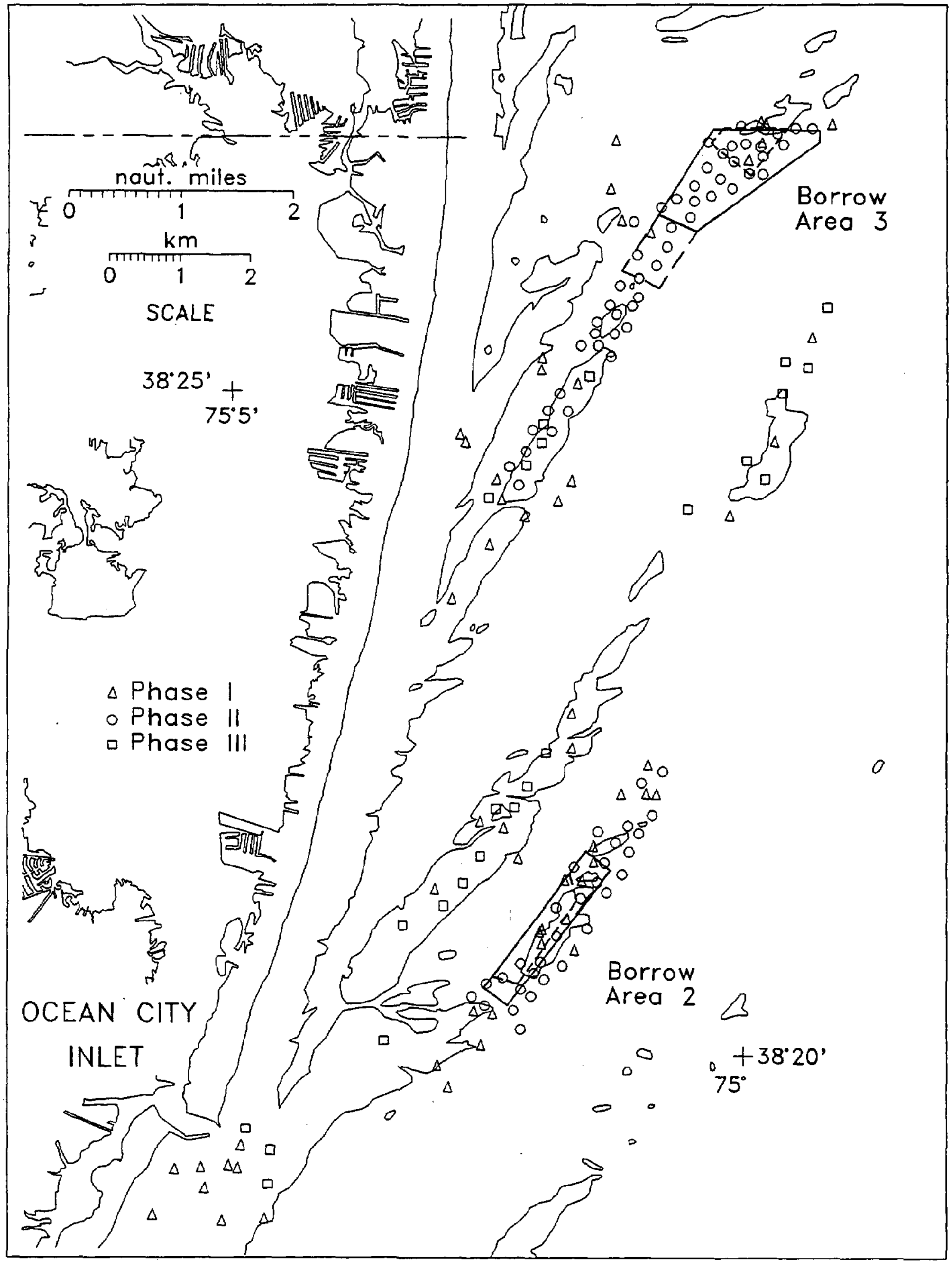


Figure 7. Vibracore locations. Vibracores are distinguished according to Phase (see Table I for dates of collection). The 10 meter isobath and boundaries for borrow areas 2 and 3 are also shown for reference.

Table I. Vibracores collection dates. The vibracores are listed according to cruise and shoal area. Vibracore locations are shown in Figure 7.

SHOAL	DATE COLLECTED			TOTAL
	Aug./Nov., 1986 (Phase I)	Nov./Dec., 1987 (Phase II)	Jan., 1989 (Phase III) (future maintenance)	
1 (ebb-tidal)	9 cores (1-1 to 1-9)		3 cores (1-12, 1-16, 1-17)	12
2 (detached)	13 cores (2-1 to 2-13)	31 cores (2-14 to 2-44)		44
3 (detached)	5 cores (3-6, 3-7, 3-9, 3-10 and 3-12)	29 cores (3-13 to 3-41)		34
4 (attached)	8 cores (4-1 to 4-8)	21 cores (4-10 to 4-30)	5 cores (4-31 to 4-35)	34
5 (attached)	4 cores (5-1 to 5-4)			4
6 (attached)	7 cores (6-1 to 6-7)		9 cores (6-8 to 6-16)	16
7 (attached)	4 cores (7-1 to 7-4)			4
8 (detached)	4 cores (8-1, 8-2, 8-4, 8-5)			4
9 (detached)	3 cores (9-1 to 9-3)		7 cores (9-4 to 9-10)	10
TOTAL	57	81	24	162

LABORATORY ANALYSES

Phase I vibracores were examined at the CERC's sediment analysis laboratory in Duck, North Carolina. The vibracore sections were split lengthwise. Core sections were described in detail, noting thicknesses of sediment units, textures, sedimentary structures, and the presence of flora and fauna. Several samples were taken for radiocarbon dating. The Carbon-14 determinations were done by the University of Texas (Fred Anders, unpublished data), the results of which are presented in Appendix I. . Lithological units were sampled from one half of the core sections by collecting a continuous channel sample through the entire length. The remaining half of each vibracore section was sealed in plastic for storage at the Maryland Geological Survey. The core sections were available for re-examination for this study along with the detailed core logs.

Sediment samples from the vibracores were analyzed for grain size distribution using the procedures outlined in Anders and Hansen (1990). The samples were first washed to separate the sand sized fraction from the finer sediments (mud content). Grain size analysis of the sand fraction was accomplished by using sonic sieves at 0.25 phi intervals, from -2.0 phi to 4.0 phi. Folk's (1980) graphical techniques were used to calculate mean and standard deviation (sorting) for the samples.

Phase II and III vibracores were analyzed at the U.S. Army Corps of Engineer's Soils Laboratory at Ft. McHenry in Baltimore, Maryland. Only those vibracore sections that were collected above the project limit (-15.24 meters NGVD) were opened. Of the 105 Phase II and III cores collected, 48 have sections that were not opened by the COE.

Phase II and III vibracore sections were opened lengthwise and gross lithologies were noted. Sediment textural descriptions were based on Unified Soil Classification System criteria and sediment color description was referenced to Munsell Soil Color Charts, 1988 ed. (U.S. Army Corps of Engineers, 1989a; 1989b). The presence of shells or shell fragments were generally indicated. However, detailed identification of shells as to genus or even class was not included. Descriptions of sedimentary features or structures also were not noted in the core logs. Channel samples were collected from each sediment unit for grain size analysis. Sediment samples were analyzed using ASTM sieves, at whole phi intervals. Folk's (1980) graphic method was used to calculate mean and standard deviation (sorting) of the grain size distribution for each sample. After examination and sampling, the halves of the sections were rejoined and taped together, with no attempt to seal or preserve the sediments. The vibracore sections were stored at Ft. McHenry in Baltimore.

For this report, the lithologic logs for all of the vibracores were reviewed in an attempt to correlate lithologies with reflectors and structures seen in the seismic records. Of the 162 vibracores, 43 were collected on or very close to existing seismic profiles, thus having some stratigraphic control for lithological interpretation. The 43 vibracores are listed in Table II.

Vibracores were selected for detailed re-examination and analyses based on several factors:

1) the quality of the seismic record on which the vibracore was located;
2) the degree of preservation of the archival portion of the vibracore;
3) general lithology of the vibracore; and
4) whether or not the vibracore had unopened sections.

Depending on the general preservation of the core, selected cores were photographed and X-rayed. X-raying was done primarily to locate and identify shell layers, specifically *Mulinia lateralis*. *M. lateralis* was selected for amino acid racemization. Unopened vibracore sections were split lengthwise and described in detail. All vibracore sections were sampled for grain size analysis. One vibracore, 4-31, contained a peat layer. The peat was sampled to determine its radiocarbon date. The analysis for radiocarbon dating was performed by Beta Analytic, Inc.

Table II. Vibracores collected on or near existing seismic survey lines.

CORE	SEISMIC LINE*	TIME FIX	COMMENTS
2-1	COE 47	0832	seismic record very poor; core collected in trough
2-4	COE 47	0836	core collected in trough area; seismic record indicates parallel structures
2-8	COE 74	1619	core collected on flank of shoal; seismic record indicates parallel structures
2-9	COE 74	1619	very close to 2-8; entire core opened
2-11	COE 74	1621	core collected on crest of shoal; seismic record indicates undifferentiated unit
2-13	MGS 10	1405	core collected on north flank of shoal; seismic record indicates parallel structures
2-17	COE 40	1505	seismic record extremely poor; obtained core from COE, bottom sections not opened
2-18	COE 47	0828	core collected on flank of shoal
2-22	COE 45		seismic record extremely poor; obtained core from COE
2-23	MGS 10	1400	entire core opened and most likely dried out; core near 2-13
2-27	COE 47	0821	core collected on north crest of shoal; seismic record indicate that core penetrated series of parallel reflectors
2-30	COE 47	0816	seismic record indicates parallel structure; core collected on east flank of shoal, close to where A1 appears to converge with surface
2-35	COE 74	1625	very short core; did not penetrate visible reflectors; entire core opened
2-43	MGS 14	1149	seismic record faint but suggests parallel structure; core collected on south flank of shoal, bottom of core not opened
3-12	COE 33 MGS 70	SOL 0810	core collected along east trough; seismic record shows parallel structures
3-16	COE 38	0834	seismic record very poor, very short core; collected on crest of shoal
3-17	COE 25 COE 38	 0839	seismic record for line 25 very good, showing prominent reflectors at -13 m and -18 m; core did not penetrate reflectors; entire core consists of sand
3-19	COE 26	1317	seismic shows reflector at -13.5 to -14 m; discrepancy with depth that core was collected, seismic indicated at -11 m but COE recorded depth of -13.7 m
3-22	COE 74	1435	seismic record shows parallel structures, prominent reflectors at -15 and -17 m; core collected on outer flank penetrating shallower reflector, entire core opened, consists of coarse sand
3-24	COE 27	1020	seismic record very poor but shows predominant reflector at -18 m; core collected on south flank of shoal, bottom two sections of core not opened
3-25	MGS 14	1026	seismic record no good
3-26	COE 38	0840	seismic record extremely poor; core taken on southwest flank of shoal, bottom of core not opened
3-41	COE 27	1012	seismic record very poor; core taken on crest of shoal, entire core sand
4-1	COE 52	1238	core collected along central axis of shoal

Table II (cont.). Vibracores collected on or near existing seismic survey lines.

CORE	SEISMIC LINE*	TIME FIX	COMMENTS
4-2	COE 65	1041	core collected in trough area
4-3	COE 70	1217	core collected on west flank of shoal;
4-4	COE 52	1221	core collected on east flank of shoal, penetrating shallow channel feature; seismic record shows somewhat chaotic structure
4-6	COE 71	1237	core collected on east flank of shoal; seismic record indicate that core penetrated shallow channel feature
4-7	MGS 12	1452	core collected on crest of shoal; seismic record shows series of parallel reflectors
4-11	COE 55	0733	seismic record shows prominent parallel structure
4-12	COE 60	0909	core collected on crest of shoal; core may have penetrated shallow channel feature
4-13	COE 62	0951	core collected on crest of shoal, penetrating shallow internal structure
4-14	COE 64	1029	core collected on west flank of shoal; seismic record indicates that core penetrated shallow channel feature
4-18	COE 52	1243	core collected near crest of shoal, penetrating prominent reflector at -12 m; bottom of core consists of fine-grained sediments
4-19	COE 52	1245	core collected along western flank of shoal; examination of core suggested that core was mislabeled (upside-down)
4-30	COE 69	1204	core collected near crest of shoal, penetrating a very interesting feature (inclined bedding), entire core opened
4-31	COE 72	1247	core collected along west flank of shoal; seismic record indicates that core penetrated shallow channel feature
4-32	COE 64	1032	core collected on flank of shoal, barely penetrating reflector at -13 m; seismic record shows series of shallow parallel reflectors in vicinity; entire core opened
4-34	COE 63	1007	core collected on crest of shoal; entire core opened
8-5	COE 52	1256	seismic record indicates core penetrated undifferentiated unit (no reflectors) but core is described as alternating gravelly, coarse sand and muddy sands
9-1	COE 47	0906	core collected on flank of shoal, penetrating undifferentiated unit
9-5	COE 44 MGS 70	0912 0841	core collected along west flank of shoal; both 3.5 kHz and Geopulse seismic records show no visible structure
9-6	COE 48	1002	entire core opened, consists of gray brown sand

* COE -conducted by U.S.Army Corps of Engineers, Coastal Engineering Research Center
MGS -conducted by Maryland Geological Survey-U.S.G.S. cooperative (see Toscano *et al.*, 1989)

For this study, interpretation of the core sediment units is based primarily on seismic data and, secondly, on lithological descriptions (particularly texture and color of the sediments). When available, radiometric dates are also used. Therefore, much of the discussion regarding the interpretation of the core sediments is generally limited to those cores that have some seismic control (*i.e*- located on or near seismic track lines).

General vibracore information, textural data and general lithologies for all of the vibracores are listed in Appendix I.

RESULTS AND DISCUSSION

SEISMIC PROFILES

Acoustic (seismic) reflectors and stratigraphic units discussed in this report will be referenced to the nomenclature devised by Toscano *et al.* (1989) as shown in Figure 2.

The seismic profiles collected by the COE consist entirely of 3.5 kHz records. The 3.5 kHz signal rarely penetrated more than 25 meters and often was reflected by a persistent horizon between 20 to 25 meters. Many of the shorter profile lines, particularly those transversing shoals 2 and 3, were not very informative because the coarse shoal sands attenuated the signal thus preventing any penetration. Additionally, shallow water depths, combined with relatively hard (sandy) sea floor, resulted in strong multiples obscuring much of the detail in the seismic record. The better seismic records (COE lines 47, 48, 51, 52, and 74) were collected in the deeper trough areas between the shoals.

M2 Reflector

Several reflectors are mapped within the study area. The first is a persistent reflector, generally marking the maximum penetration of the 3.5 kHz signal. This reflector is present in most of the seismic records. The depth of this reflector is -15.5 meters NGVD within 1 kilometer offshore and increases to -30.0 meters 8 kilometers offshore. In the nearshore area, the signature of the reflector is very strong (Figure 8) and attenuates somewhat under shoals and in the offshore direction. This reflector is extremely flat showing very little channelling or local relief.

Figure 9 shows the structure contour (depth below NGVD) of the surface defined by this reflector. This surface, the strike of which parallels the axes of the linear shoals, dips to the southeast at approximately 1.4 meters per kilometer. This horizon is interpreted to be the M2 horizon, which separates Q2 lithologic unit from the underlying Q1 unit (see Figure 2). This interpretation is based on the depth and character of this reflector and its relative position to another deeper reflector visible in the Geopulse (200 joules) seismic records. The M2 horizon represents oxygen-isotope stage 6 (~ 190 to 130 ka) erosional surface and has been correlated to the Eastville downcut of the Susquehanna (Toscano *et al*, 1989).

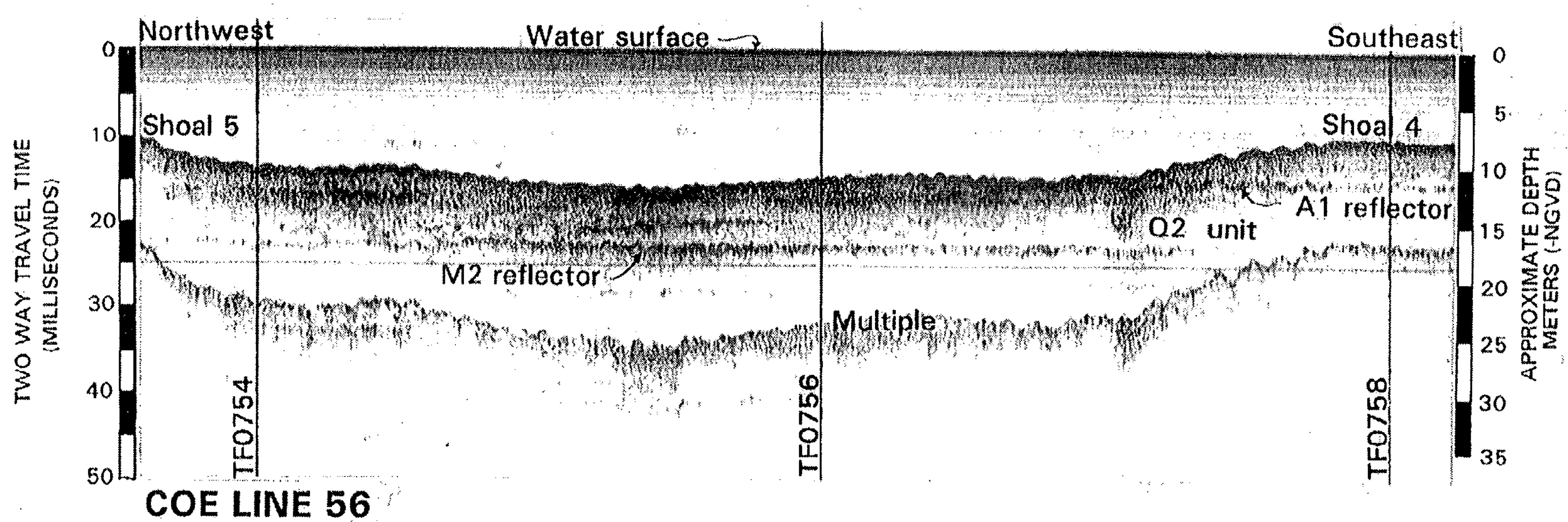


Figure 8. Section of seismic record (ORE 3.5 kHz) for COE line 56. The M2 reflector is very prominent in the inter-shoal areas and attenuate beneath the shoals. Refer to Plate 1 for interpretation of entire profile line.

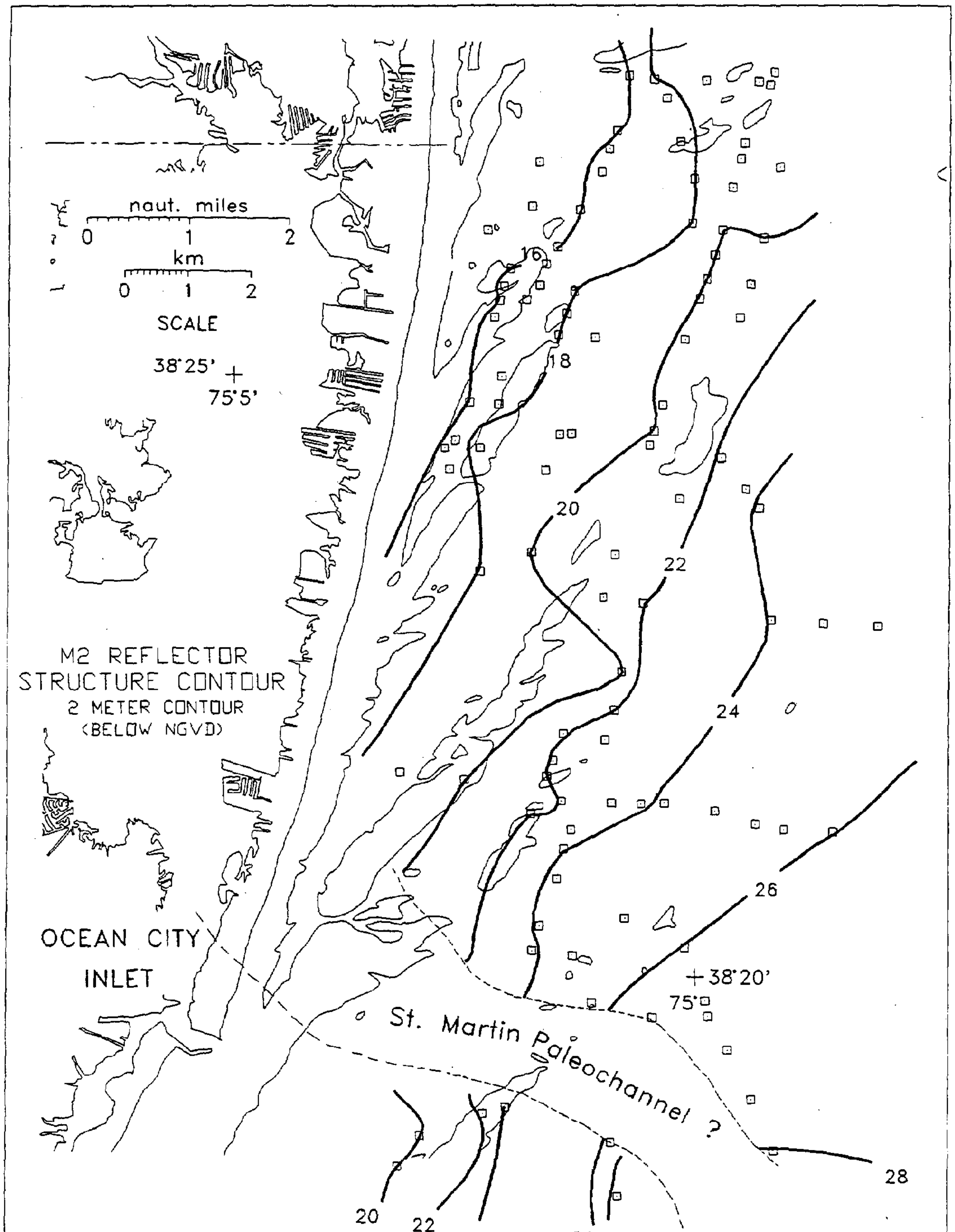


Figure 9. Structure contour of M2 reflector. Open squares indicate data points. Depths to the M2 reflector were taken primarily from ORE 3.5 kHz seismic records. The contour interval is 2 meters (below NGVD). The 10 meter isobath is shown for reference.

M1 Reflector

A deeper reflector, 5 to 6 meters below the M2, is visible in the Geopulse records but rarely in the 3.5 kHz records. Because the Geopulse seismic records tended to deteriorate in the onshore direction, sufficient data points were not available to construct a structure contour map for this acoustic horizon within the study area. However, on several of the Geopulse lines, particularly MGS line 30 (see Figure 6 for location), this deeper reflector is visible and truncates inclined bedding and channelling, a character associated with the M1 reflector (Toscano *et al.*, 1989).

Paleochannels and Associated Fill Deposits

The St. Martin paleochannel is not clearly visible in any MGS or CERC seismic records collected north of MGS line 16 which is located off Assateague Island, at approximately 38°14'N latitude (see Toscano *et al.*, 1989—Plate I). However, several seismic records show the M1 and M2 reflectors either dipping below the penetration depth of the seismic signal or being truncated by a third reflector interpreted to be the M3. These locations where the M1 and M2 reflectors disappear are interpreted to be the extreme edges of the St. Martin River paleochannel. The boundaries for the St. Martin River paleochannel, based on these locations, are shown in Figure 9. The width of the paleochannel varies from 1500 to 2500 meters, which is on the same order of magnitude as the dimension given for channel #9 (Toscano *et al.* 1989, Table XV).

Several smaller, relatively shallow paleochannels were also evident in the 3.5 kHz seismic record. Thalweg depths range from -18 to -26 meters NGVD, which fall within the range of depths for paleochannels mapped by Field (1980) in the same area. Figure 10 presents a segment of the seismic record for COE line 74 featuring one of these paleochannels. This particular paleochannel is located on the northeast flank of shoal 6.

Visible in many of the COE seismic lines collected over shoals 4 and 5 are several broad paleochannels that cut into the underlying Q2 unit. Plates 1, 2, and 3 present selected interpreted seismic profiles featuring these paleochannels. The close spacing of the multiple seismic lines has allowed mapping of these shallow channels, the extent of which is shown in Figure 11. These channels trend in a northwest-southeast direction and can be traced to the channels further offshore. Thalweg depths range from -14 to -20 meters NGVD with the depths increasing in a southeasterly direction. The deepest portions cut below the M2 horizon.

Internal chaotic reflectors within the paleochannels define a variety of fill sequences. Several episodes of cut and fill are evident based on nested channels (smaller channel with a larger one) seen on COE line 69 (Figure 12). The shallower channel in COE line 69 (time fix [TF] 1203 to 1207), is also seen in lines 64 (TF1028 to 1030) (Plate 2), 70 (TF1214 to 1219), and 71 (TF1236 to 1239) (Plate 3). This shallow paleochannel lies directly under shoal 4, trending parallel to the shoal axis, but cuts diagonally across the broad deeper paleochannel. The trend of the shallow channel is shown in Figure 11 (stippled area along shoal 4). Internal

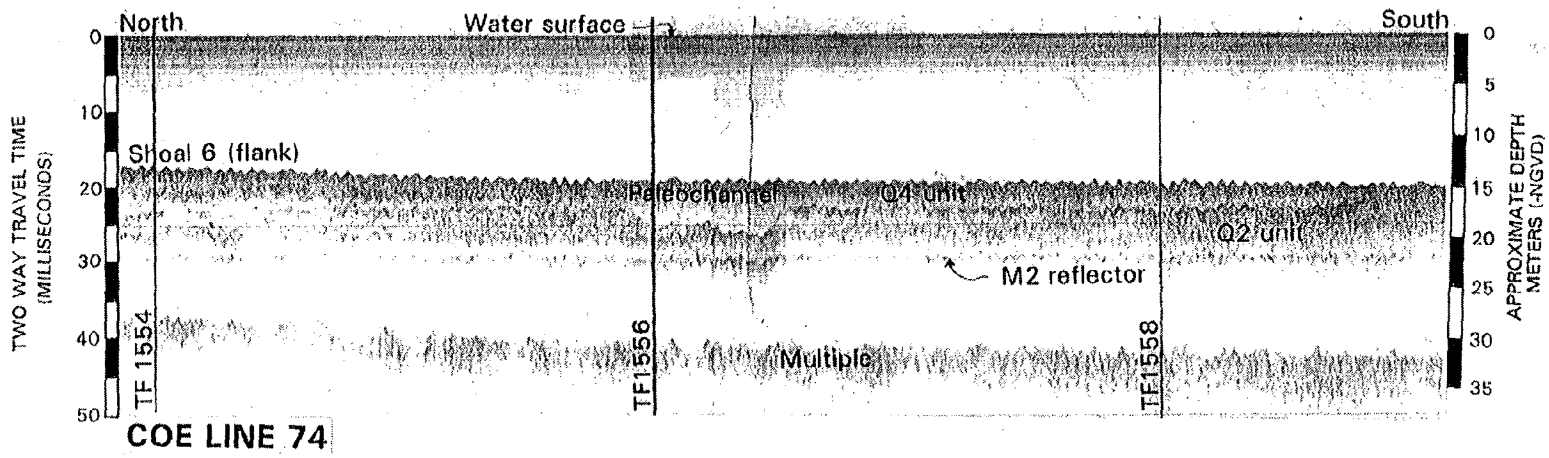


Figure 10. Section of seismic record (ORE 3.5 kHz) for COE line 74 featuring broad shallow paleochannel. This paleochannel extends under shoal 6 north of the track line.

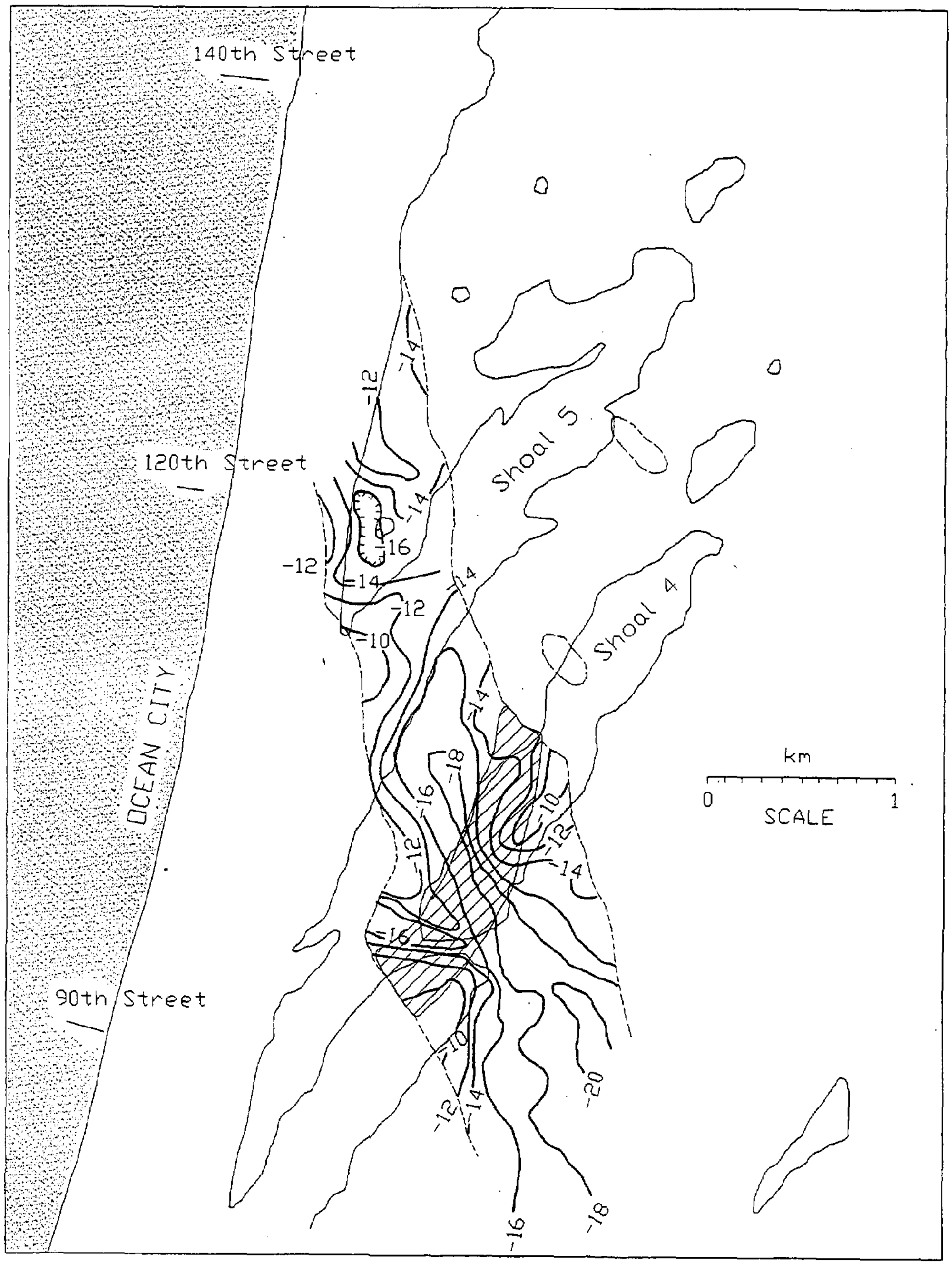


Figure 11. Areal extent of early Holoçene Q4 depositional unit (indicated by dashed lines) with structure contour of the paleochannels. Contours were reconstructed from paleochannel depths taken from seismic records (ORE 3.5 kHz). The stippled area parallel to shoal 4 indicates the general trend of a shallower (younger) channel sequence, possibly tidal or inlet related. This shallow channel is particularly noticable in the seismic records for COE lines 64, 69 (see Figure 12 for section of line 69), 70 and 71. The 10 meter isobath outlining the general shape of the shoals is shown for reference.

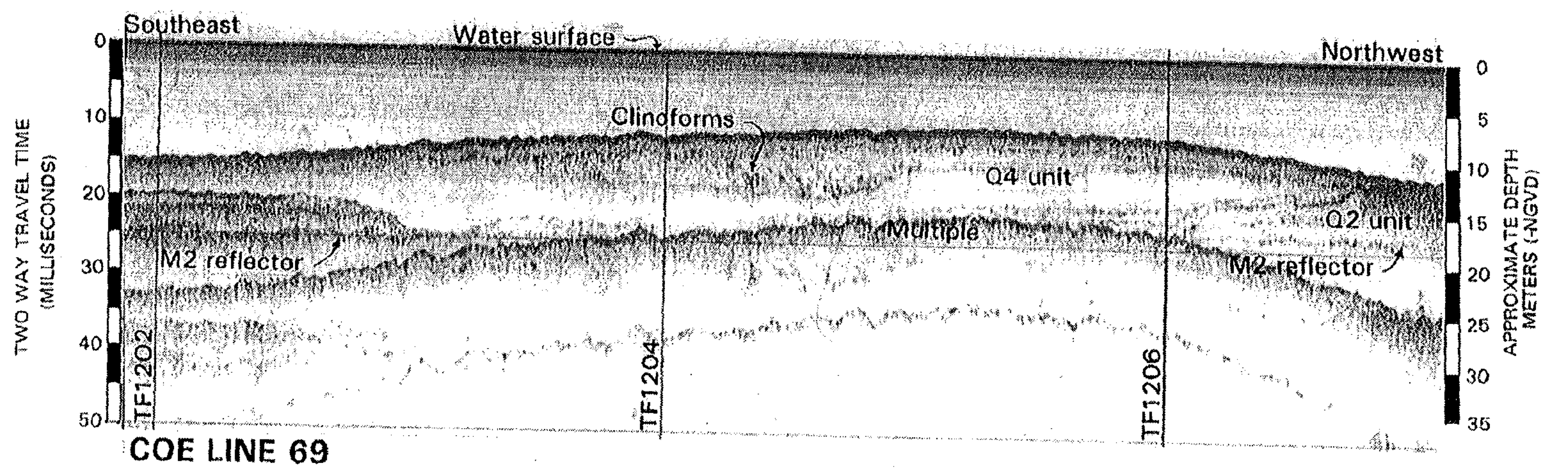


Figure 12. Section of seismic record (ORE 3.5 kHz) for COE line 69. This seismic record crosses shoal 4 and features broad paleochannel incised into the underlying Q2 (see Plate 3 for interpreted profile). Internal reflectors show several episodes of cut and fill. Fill features in the shallower channel suggest clinoforms. The shallow channel is interpreted to be an laterally aggrading channel, either tidal or inlet related.

reflectors revealing clinoforms or foreset bedding suggest that the shallow channel migrated to the (south)west.

A1 Reflector

Another, usually planar, reflector often marks the base of the shoals and is particularly noticeable in the seismic records transversing shoals 2, 3 and 9. This reflector, labeled by both Field (1976, 1980) and Toscano *et al.* (1989) as the A1, represents the boundary between the ravinement surface formed by shoreface erosion and modern trailing edge shelf deposits and is equivalent to the upper ravinement unconformity described by Belknap and Kraft (1985). The A1 reflector generally is not evident in the seismic record in the nearshore west of the shoreface zone (less than -10 meters NGVD).

Figure 13 shows the general trend of the A1 reflector, the depths taken from the 3.5 kHz and the selected Geopulse (200 joules) seismic records. The A1 contour map was constructed to better define the base of the shoals and was very useful in the interpretation of the vibracore lithologies. The A1 reflector is discontinuous, nonexistent in the trough areas where the underlying depositional units are exposed. The trough areas where the A1 reflector is nonexistent is indicated by dashed structure contours in Figure 13. The A1 surface is slightly undulating with little local relief. The strike of the A1 surface is parallel to the axis of the existing linear shoals. The surface dips to the southeast at 1.7 meters per kilometer, slightly steeper than the M2 horizon. Depths to the A1 ranged from -9.5 m NGVD in the nearshore area (approximately 0.5 kilometers offshore of 100-120th Streets in Ocean City) to -18 meters 5.2 kilometers offshore.

CHARACTERISTICS AND DISTRIBUTION OF SEDIMENTS

The majority of the 162 vibracores were collected on the crest and flanks of the shoals and between the depths of -9 and -14 meters NGVD. Over 500 sediment samples were taken from the vibracores and analyzed for textural characteristics. The results are listed in Appendix I. Because the vibracores were collected on the shoals as opposed to trough areas, it is expected that there would be a sampling bias toward coarser-grained sediments. Regardless of this bias, a general analysis of the statistical parameters of the core samples was conducted to see if there are any local trends within the study area. The sediment samples were given equal weight statistically regardless of the depth intervals (thicknesses) they represented. Only those samples for which grain size data (mean, sorting, mud and gravel contents) were available were considered in the tabulations. The statistics are summarized in Tables III and IV.

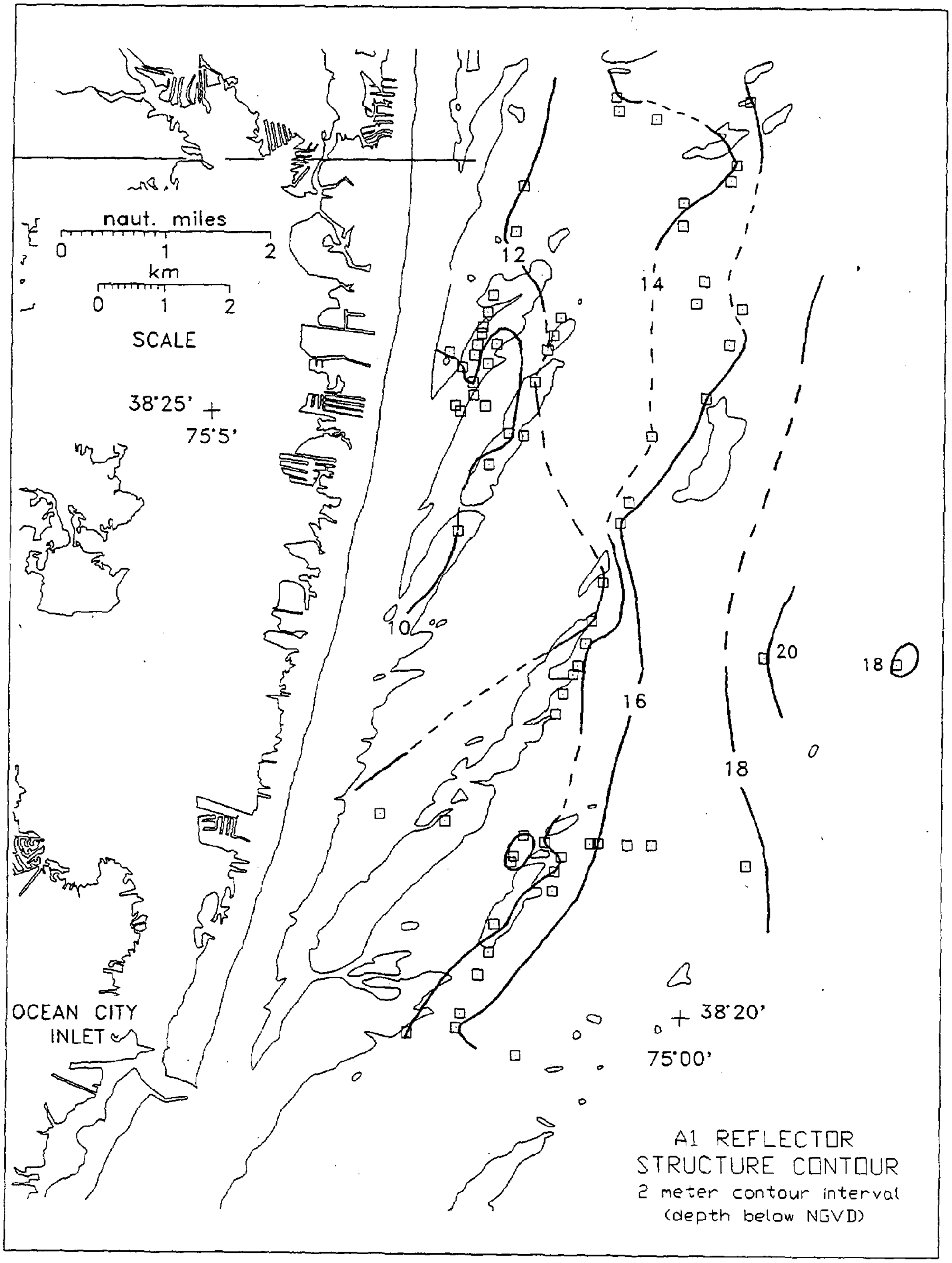


Figure 13. Structure contour of A1 reflector. Open squares indicate data points. Depths to the A1 reflector were taken primarily from ORE 3.5 kHz seismic records. The A1 reflector is discontinuous, absent in the trough areas where the underlying depositional units are exposed. These areas are indicated by dashed structure contours. The contour interval is 2 meters (below NGVD).

Table III. Average and range of the mean grain size values (phi) of the vibracores samples for 2 meter intervals (depth below NGVD). The mean grain size values for the sediment samples are listed in Appendix II.

Depth (m) below NGVD	Average Mean	Range of Means	*n*[*]
< -6	1.93	0.81 to 2.35	11
-8 to -10	1.78	0.87 to 2.97	28
-10 to -12	1.83	0.09 to 5.02	78
-12 to -14	1.97	-0.65 to 6.97	140
-14 to -16	2.04	-0.75 to 5.32	167
-16 to -18	2.06	-0.08 to 3.25	45
-18 to -20	1.85	-0.30 to 3.04	17

[*] Number of samples having lower depth interval falling within the specified depth interval. Mean grain size values for the samples were averaged to obtain average mean.

According to the Folk (1954) classification (Figure 14), 73% of the analyzed samples are sand (S) with mean grain size falling between 1 and 3 Φ (medium to fine sand). The mean grain size of the samples decreases slightly with increasing depths down to -18 meter NGVD (Table III). Sediment samples become coarser and less sorted in the northerly direction. When only samples taken from the top (50 cm or less) of the vibracores are considered, this coarsening trend is more pronounced (Figure 15).

Gravelly sands (gS) and sandy gravels (sG) make up approximately 12% of the samples. Generally, samples with gravel contents greater than 30% represent sediment intervals of several centimeters. However, vibracores 8-2 and 8-5 contained over a meter of gravelly sediments with gravel contents between 47% and 60%. Eighty-seven percent of the sediments sampled from vibracores collected on Shoal 3 contained gravel (Table IV).

Approximately 14% of the sediment samples analyzed contained a significant amount of mud; *i.e.*- mud (M), sandy mud (sM), muddy sand (mS), and gravelly muddy sand (gmS). The number of muddy samples is under-representative because the fine-grained units in the vibracores often were not analyzed for texture and, therefore, not included in the tabulations. Most of the muddy sediments analyzed were sampled from the vibracores collected on shoals 2 and 4.

Table IV. Summary of gravel and mud contents of vibracores samples for each shoal area. *n* is the number of sediment samples used in the calculating the averages in each category. Only those samples containing greater than 1 % gravel or mud were included in calculating average gravel and mud contents.

Shoal	Number of cores	Gravel content		Mud content		Mean Grain Size (Phi)	
		Ave. %	*n*	Ave. %	*n*	Ave Mean	*n*
1	12	8.30	8	4.48	7	1.78	29
2	44	6.22	37	6.78	77	2.04	133
3	34	5.21	78	3.90	42	1.30	89
4	34	5.56	45	14.99	104	2.33	139
5	4	2.25	4	13.24	8	2.39	11
6	16	10.38	3	21.39	13	2.02	39
7	4	4.79	4	9.00	12	2.22	13
8	4	17.46	12	7.97	16	1.81	22
9	10	5.96	5	1.73	6	1.69	25

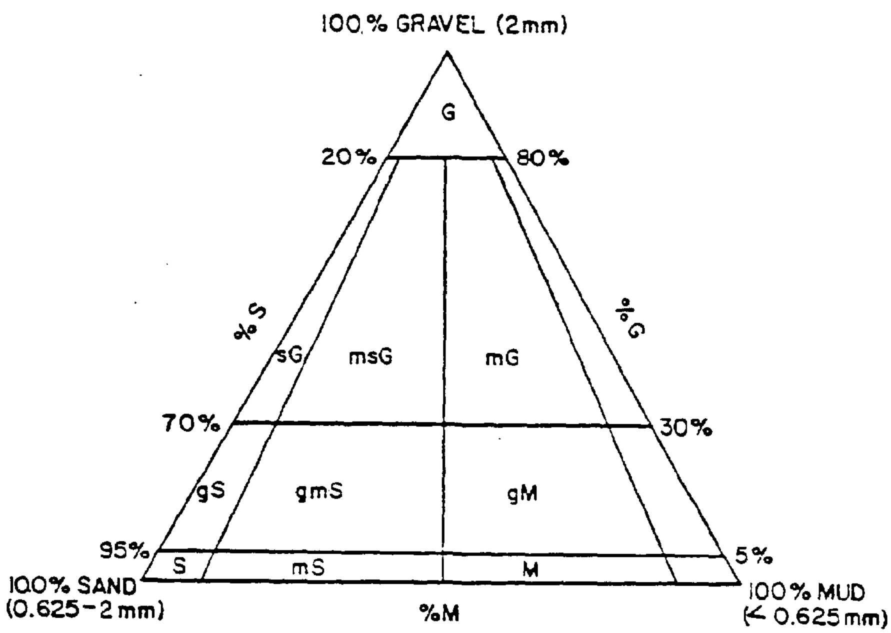


Figure 14. Folk (1954) classification.

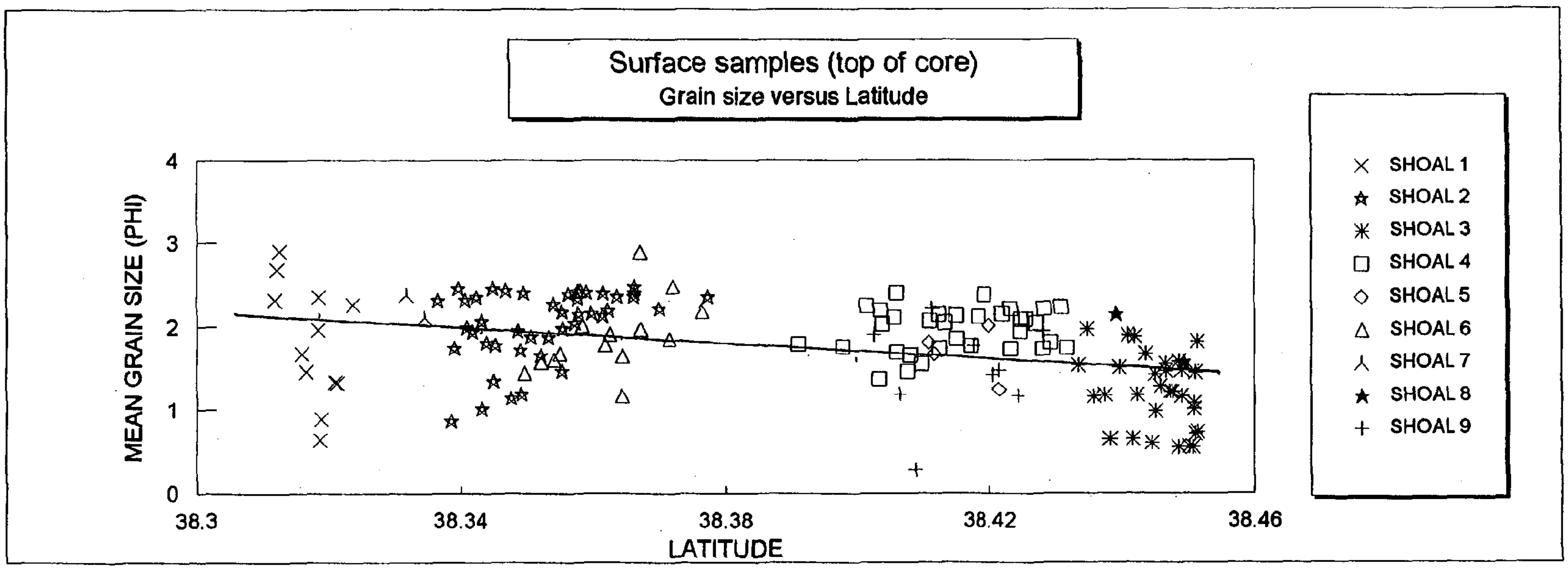


Figure 15. Plot of mean grain size (phi) versus latitude for sediments samples taken from the top of the vibracores.

STRATIGRAPHIC INTERPRETATION OF VIBRACORE SEDIMENT UNITS

Since most of the cores were collected on the crest of the shoals, a large portion of the sediments sampled represented modern transgressive shoal sands (Q5). Nevertheless, at least two other distinct stratigraphic units were penetrated: Pleistocene depositional sediments (Q2), and early Holocene transgressive, leading edge sediments (Q4). A fourth unit (Q1), which is stratigraphically below the Q2 unit, may also have been penetrated. Based on projected depth of the M2 horizon, several vibracores (cores 3-32 through 3-40) should have penetrated the Q1 depositional unit. These cores are located in the trough area between shoals 3 and 4, where the M2 horizon is mapped -17 to -18 meters NGVD. The penetration depth for the cores ranges between -18.5 meters to more than -19 meters NGVD. However, the bottom sections of all these cores were never opened by COE. Because seismic control in this area is very poor, none of these cores were selected for examination in this study.

Certain characteristics were used to distinguish Pleistocene sediments from the younger Holocene sediments. Pleistocene sediments are usually much more firm or compact and are often oxidized resulting in a mottled appearance or striking color differences. Pleistocene muds are often described as being very firm or "fissiled." Toscano *et al.* (1989) repeatedly described Pleistocene Q2 muds as "dewatered", indicating their dry texture. Halsey (1978) noted that Pleistocene lagoonal muds were often aquamarine-blue to greenish-gray, distinguishing them from the overlying dark gray Holocene sediments. Belknap and Kraft (1985) identified Pleistocene (pre-Holocene) sediments, including sand and gravel, as being more weathered, containing leached shells and iron oxide staining, and having older radiocarbon dates. McDonald (1981) considered sediments yielding radiocarbon dates older than 13,000 years as Pleistocene in age.

When reviewing the core logs for this study, descriptions containing certain key words were noted in identifying older, Pleistocene sediments. Sediments that were described as "green" or "olive" in color or iron stained, having an orange or red color, or as having "dry", "compact" or "dewatered" textures were interpreted to be possible Pleistocene-age sediments.

Stratigraphic Unit Q2- Pleistocene Deposits

Seismic records show the Q2 unit to be very close to the surface of the sea floor, cropping out in the deeper trough areas. The M2 horizon, which marks the lower boundary of the Q2 depositional unit, lies between -16 and -26 meters NGVD. The thickness of Q2 deposits vary from 4 to 8 meters within the study area.

The 6-meter vibracores collected in the inter-shoal troughs and along the outer shoal flanks generally penetrated the Q2 sediments unless seismic data indicated otherwise. The dark-colored, finer-grained sediments (*i.e.* dark greenish-gray, fine sand with mud contents greater than 5%) were identified in the cores at depths below the A1 horizon and, therefore, were interpreted to be Q2.

Shoal 2

Seismic data indicate that shoal 2 directly overlies a 4 to 5-meter thick, fairly structureless, unit interpreted to be the Q2 depositional unit. The depth of the A1 reflector is approximately -13 to -14 meters (NGVD) in this area. Vibracores 2-1, 2-4, 2-6, 2-8, 2-14, 2-18, 2-19, 2-23, 2-25, and 2-27, which were collected at the north end of shoal 2 (Figure 16), contained interbedded gray fine sands, dark-colored sandy muds, and muddy sands, interpreted to be Q2 deposits. Examples of this unit are described in detail in cores 2-8 and 2-27. Detailed lithologic logs of the cores are presented in Appendix II.

Vibracore 2-8, located on COE line 74 (TF 1619), penetrated approximately 3.5 meters of modern shoal sediments (tan medium sand) before reaching the underlying unit. The top 3.6 meters of this core consisted of medium sand with some shells and occasional mud laminae toward the bottom of the section. A sharp contact, which was interpreted as the A1, was noted at -3.66 meters (-14.02 meters NGVD). Sediments changed to reddish-orange coarse sand, grading into interbedded sand and mud laminae. The bottom 2.5 meters of the core consisted of finely interbedded fine gray sand, dark greenish-gray muddy sand, and clay. Some peat clasts were noted toward the bottom of the core. Shells found in the core include *Macoma* and *Nassarius*. None of these shells were suitable for amino acid racemization dating.

Vibracore 2-27 was collected on the eastern flank of shoal 2. The core location falls very close to COE line 47 (TF 0821). The COE reported the core was collected in 14.9 meters of water; however, the seismic records indicate the water depth to be 13.5 meters. Lithologic sequences found in the core seemed to correlate with the seismic data, suggesting that the core was collected in the shallower water depth.

The top 1.24 meters of core 2-27 consisted of dark gray fine sand with abundance of shells and shell fragments. Shells include *Spisula, Busycon* (juvenile forms), *Macoma, Mullinia,* and *Neverita* which are modern species. This top unit is interpreted to be modern sands (Q5). A sharp lithologic contact was present a -14.74 meters NGVD, coinciding with the depth of the A1 horizon. The remainder of the core, interpreted to be Q2 sediments, consisted of dark olive-gray fine sands interbedded with thin layers (2 to 4 centimeters thick) of sandy mud. Sand content increased down core. Shells were common with *Nassarius* being the most abundant in the upper sections. Other shells included *Macoma* and *Ensis*. The bottom two meters of core were barren of shells. As with core 2-8, no shells (i.e.- *Mulinia*) suitable for amino acid dating were found. The core did not reach the M2 horizon, projected to be at -22 meters.

Shoals 3 and 8

Thirty-four vibracores were collected from the area around shoal 3, in the northern part of the study area. Seismic data indicate the shoal sands directly overlie the Q2 unit. The A1 horizon is mapped between -13 to -16 meters NGVD, becoming more shallow toward the northwest (Figure 13). Based on penetration depths, 24 cores should have penetrated the A1

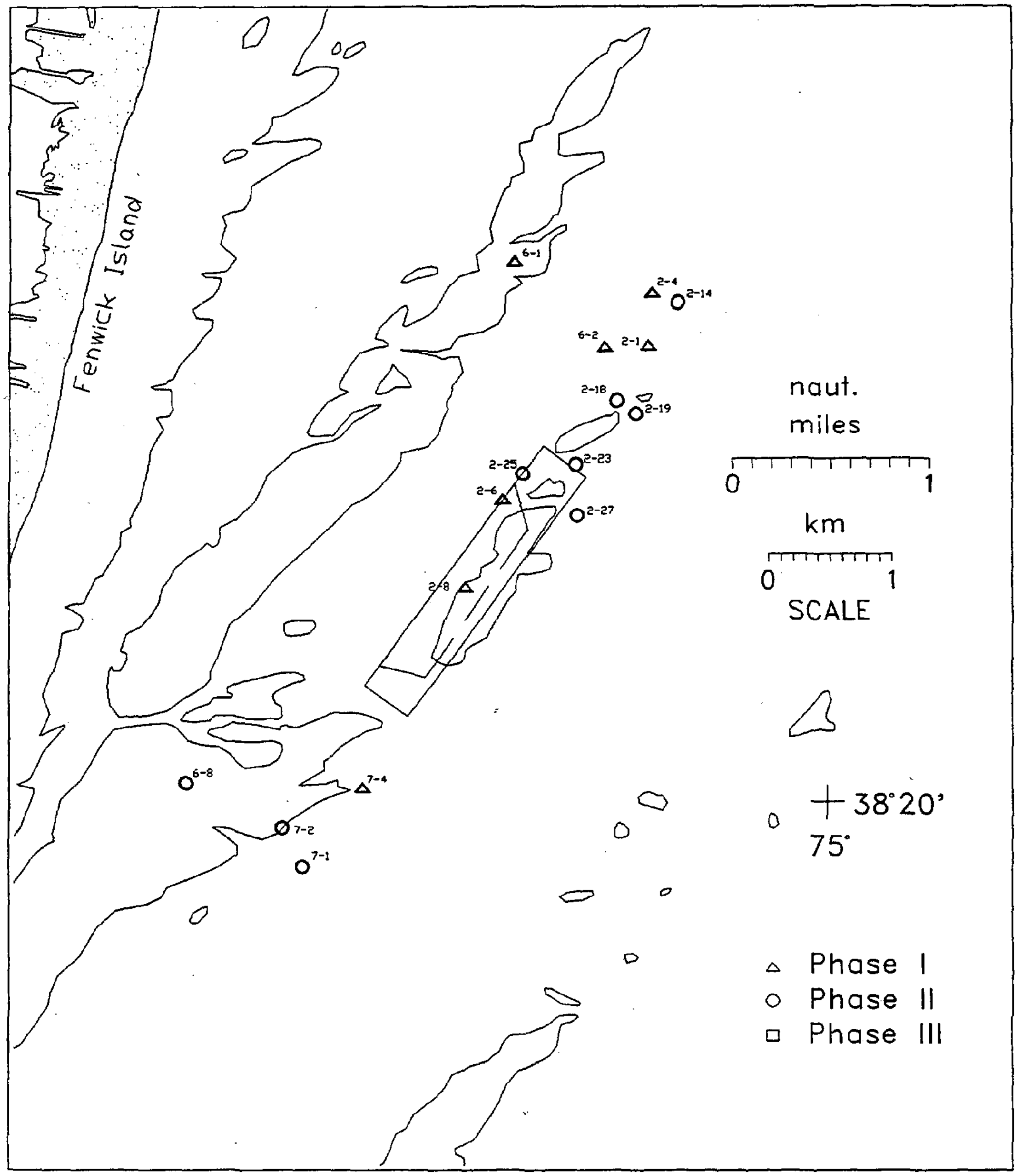


Figure 16. Shoal 2 vicinity detailing borrow area dredging limits and selected core locations. The State contract (Phase I) dredging area is indicated by the dashed lines within borrow area. The cores shown are discussed in the text.

horizon. Eight cores (3-10, 3-12, 3-14, 3-24, 3-30, 3-36, 3-39, and 3-40) contained sequences of dark-colored, fine-grained sediments (*i.e.*, mud contents > 5%) below the projected A1 horizon. The remaining cores penetrating the A1 horizon may also contain Q2 sediments; but, sections of these cores were not opened or examined.

Core 3-12 was collected at a depth of 12.5 meters (NGVD) on the extreme northeastern flank of shoal 3 (Figure 17). This core contained a 2-meter thick sequence of alternating dark gray, dewatered clays, and silty, very fine sands from -13.55 to -17.47 meters NGVD (Appendix II). A sample of organic-rich clay, taken at -15 meter NGVD by the COE, yielded a Carbon-14 date of 32,240 +/- 1520 years B.P. This date approaches the limit of the radiocarbon dating technique and, therefore, is interpreted with caution. This date is considered to be a minimum estimate of the actual age of the sediments.

The Q2 units in many of vibracores included sequences of gravel and medium to coarse sand along with the muds (see 3-10, 3-12, 3-36, and 3-40). Overall, the Q2 sediments around shoal 3 appear to be coarser than those encountered around the shoal 2 area.

Iron-stained sand and gravelly sands were found in vibracore 8-4, collected west of shoal 3 (Figure 17). This core also contained a unit of interbedded sand and mud with peat fragments above the iron-stained sediments. The peat (at -14.25 meters NGVD) yielded a Carbon-14 date of 10,710 ±140 yrs B.P. (Fred Anders, unpublished data). This date plots too high on the Holocene sea level curve for Delaware (Belknap and Kraft, 1977), suggesting that the peat either has been reworked or transported to the site of deposition, or represents an upland swamp. Another possibility is that the peat is Pleistocene in age (Q2) but had been contaminated yielding a radiocarbon date much younger than its actual age.

Assuming that the sediment sequence containing the peat is Holocene in age, the underlying iron-stained sands could represent slightly older fluvial Q3 deposits. However, no seismic profiles were collected in this immediate area to confirm the presence of a fluvial channel. Furthermore, it is unlikely that a channel containing Q3 deposits exists in the nearshore area adjacent to the Maryland-Delaware State Line as this area corresponds to the drainage divide between Delaware River and St. Martin River watersheds (see **CONCLUSIONS AND SUMMARY**). Therefore, the iron-staining of the sands found vibracore 8-4 most likely is a result of subaerial exposure of Q2 deposits during the most recent low sea level stand (oxygen isotope stages 2 and 3).

Shoal 4

The northern half of shoal 4 directly overlies Q2 deposits. Seismic records show several small shallow channels incised into the Q2 unit in this area, but the associated fill deposits are very localized. The A1 is mapped at -10 to -13 meters NGVD in this area (Figure 13). Many of the cores collected north of COE line 63 most likely penetrated the Q2 depositional unit. However, based on the core logs, the Q5-Q2 contact in most cores was not distinct.

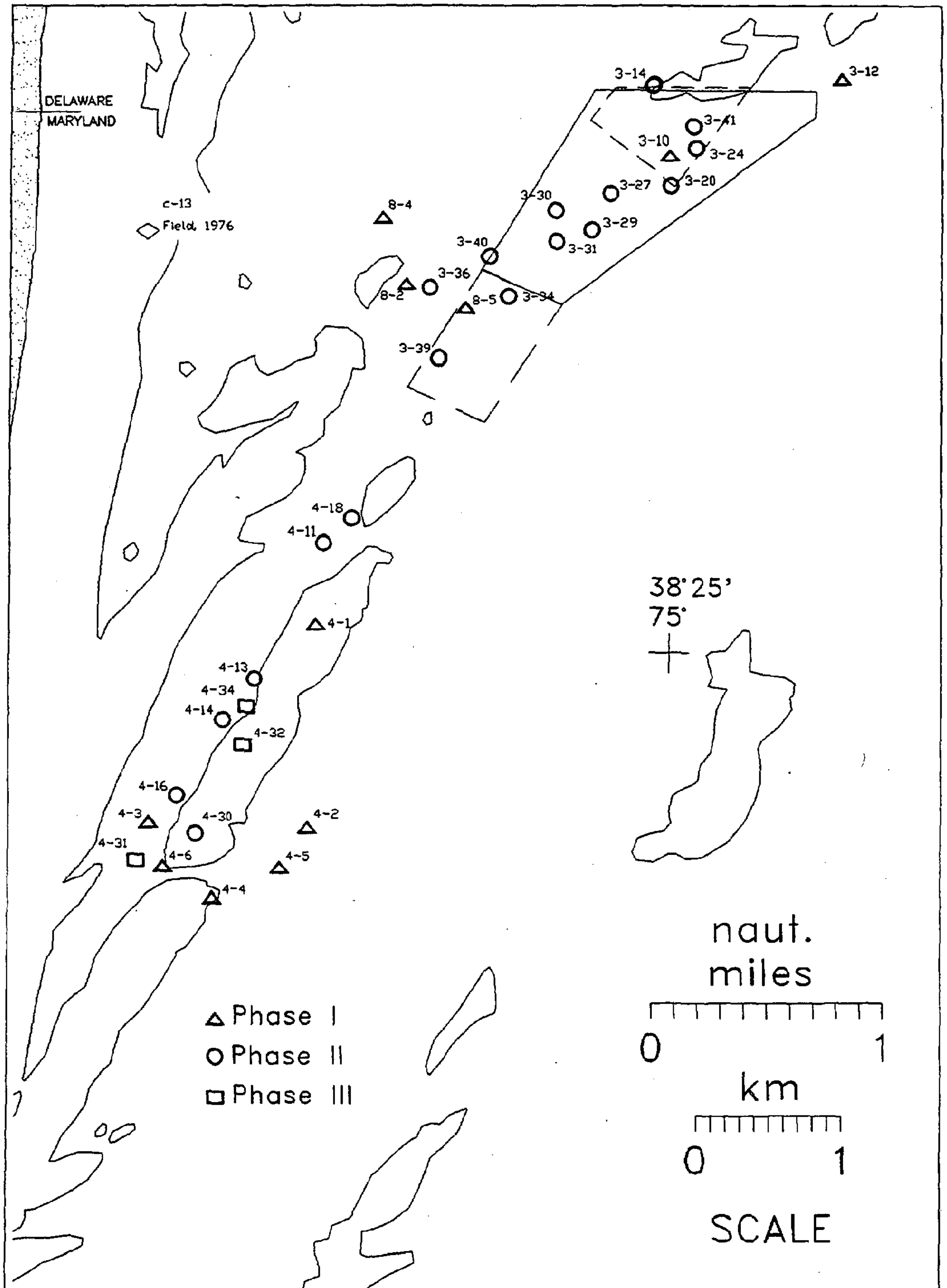


Figure 17. Shoals 3 and 4 and vicinity detailing borrow area dredging limits and selected core locations. The subarea shown within the north end of the borrow area was dredged during Phase I (State contract). Sub-area 3-III, indicated by the dashed lines at the southwest end of the borrow area, was dredged in the summer of 1992 for sand to repair storm damages in Ocean City. The cores shown are discussed in the text.

Vibracores 4-1, 4-11, 4-18, 4-32, and 4-34 are located on or near existing seismic profiles that indicate these cores penetrated the underlying Q2 sediments. Cores 4-1, 4-11, and 4-18 contained dark gray mud and muddy sand below a depth of -14 meters NGVD. Examination of the actual cores revealed a gradual fining downward sediment sequence between -12 and -13 meters NGVD, approximate depth of the A1 horizon. Vibracores 4-34 located on COE line 63, and 4-32 located on COE line 64, are shown with interpretive seismic lines on Plates 1 and 2, respectively. Both cores penetrated muddy sand at -11.8 meters and -11.2 meters NGVD, respectively. These muddy sediments are interpreted as Q2 deposits based on seismic data.

Unit Q3- Pleistocene-Holocene Fluvial Sediments

The southern end of shoal 2 and shoal 7 may overlie portions of the St. Martin paleochannel (Figure 9). Cores 7-1, 7-2 (refer to Appendix II for core logs), and 7-4, collected on the southeast flank of shoal 7 (Figure 16), contained orange (iron-stained) sand and gravel and were barren of shells. These sand sequences are characteristic of fluvial sediments, possibly representing the Q3 fill deposits (Toscano *et al.*, 1989). Seismic data in this area is very poor or non-existent precluding more conclusive interpretation of the sediment units contained in these cores.

Stratigraphic Unit Q4- Early Holocene Sediments

The southwest ends of shoals 4 and 5 overlie a series of paleochannels incised in the Q2 depositional unit. Seismic profiles show a complex sequence of cut and fill deposits in the paleochannels. Many of the vibracores collected within this area penetrated these fill units.

Examination of the archival portions of the vibracores indicates the Holocene fill sediments are often distinctly different from the fine grained sediment sequences interpreted to be Q2 deposits. The Holocene sediments were less compacted (in core sections that had not dried out completely) and appeared much darker in color. These sediments were often described as dark gray to black sediments. However, these sediments were difficult to distinguish from older sediments based solely on the review of the core logs. Fortunately, many of the cores were collected on or near existing seismic profiles. Locations of some of the vibracores are shown on the interpreted seismic profiles in Plates 1, 2, and 3.

Core 4-31, collected on the west side of shoal 4, penetrated a small channel (Plate 3, COE line 72, TF 1248). This core contained a peat layer at -14.32 meters (NGVD) that yielded a Carbon-14 date of 5,570 +/-70 yr B.P.(6410 +/-80 yr B.P. MASCA-corrected years (Ralph *et al.*, 1973)). This peat is interpreted as a fringing marsh peat; the depth and age is consistent with the mid-Atlantic Holocene sea level curve of Belknap and Kraft (1977). Overlying the peat layer was a 2.5-meter-thick unit of interbedded, tan to gray fine sand, dark gray silty sand, and gray to black mud. This interbedded unit coarsened upward. Shells and shell fragment were present including *Littorina*, *Crepidula*, and *Modiolus*. The gastropod *Nassarius* was very abundant throughout this unit. This unit is interpreted as a transgressive leading-edge estuarine channel deposit. Modern shelf sands comprise the top 2.5 meters of sediments in this core. Similar sequences of sediments were preserved in cores 4-2 (Plate 2: COE line 65, TF 1041) and 4-6 (Plate 3: COE line 71, TF 1237).

Vibracores 4-3, 4-4, 4-5, 4-13, 4-14, 4-16, and 4-30 also may have penetrated the early Holocene (Q4) deposits. Vibracores 4-3 (Plate 3: COE line 70, time fix 1217), 4-14 (Plate 2: COE line 64, time fix 1029), and 4-30 (Plate 3: COE line 69, time fix 1204) penetrated a shallow channel (tidal?) feature under shoal 4 (refer to Figure 11). The sediment units preserved in the cores consisted of brown to gray, fine to very fine sand and dark gray muddy fine sand. Examination of core 4-3 revealed a fining upward sequence of brown to gray, fine to very fine sand interspersed with thin layers of dark gray, muddy fine sand. Whole, well preserved specimens of the gastropod *Nassarius* were common; shell fragments included *Spisula* and *Ensis*. This sequence is interpreted to be a tidal channel sequence similar to that described by Elliott (1986). Core 4-30 was not available for examination but the core log indicates sediment sequence similar to that contained in core 4-3. Core 4-14 also was not available for examination but the core log suggests a coarsening upward sequence of very fine to medium sand, interpreted to be a sand bar associated with the tidal channel sequence.

Lithological and radiocarbon data suggest that additional Holocene (Q4) deposits exist elsewhere along the shoreface in Maryland. Core 13 collected by Field (1976) in the northern part of the study area (Figure 17) contained organic-rich sediments at -10.8 meters (MSL) that yielded a Carbon-14 date of 5765 ± 105 yrs B.P. Sediment sequences similar to those preserved in shoal 4 cores were found in cores collected from shoal 6 (Figure 16). Cores 6-1, 6-2, and 6-8 contained dark gray to black muddy sands. Core 6-8 contained a peat layer at -13.17 meters (NGVD). This core was originally analyzed in 1986 by COE personnel but was not sampled for Carbon-14 dating. When the core was re-examined in this study, the peat had become contaminated, precluding Carbon-14 dating analysis. These sediment are tentatively interpreted to be Q4 lagoonal deposits; however, seismic surveys were not conducted in the area of shoal 6 to confirm this interpretation.

Stratigraphic Unit Q5- Modern Shelf Sediments

Most of the vibracores presented in this study contained transgressive, trailing-edge shelf (Q5) sands which overly the Q2 and Q4 units. These modern shelf sediments discontinuously blanket the offshore in the form of linear shoals. Seismic and core data show that Q5 deposits are very thin or absent in the trough areas between the shoals and on portions of shoals 4 and 5. Maximum thicknesses of the Q5 deposits are found along shoal crests, as much as 5 to 8 meters thick along the crests of shoals 3 and 9 respectively. Many of the 6 meter-long vibracores collected on the crests of shoal 3 and shoal 9 consisted entirely of Q5 sediments.

These shelf deposits are clean, tan to light gray, moderately well to well sorted sands, ranging in mean grain size from less than 0 Φ (coarse sand) to 3 Φ (very fine sand). Gravel contents vary with some samples containing up to 50% gravel (refer to Appendix I- Table V, cores 3-12, 8-2, and 8-4). Higher gravel contents were found generally at depth (below the sea floor), although gravelly sands were found at the top of several cores collected from shoal 3 (cores 3-27, 3-29, 3-31, 3-34, and 3-41). Mud contents rarely exceed 5%. The most common shell found is *Spisula solidissima*.

Distribution of surficial sediment size relative to shoal bathymetry for several shoals reveals patterns similar to those reported by Swift and Field (1981) for linear shoals. The coarser sands are found along the crests and landward (west) flanks of shoals 2 and 9, both detached shoals, whereas the finer-grained sediments are located along the crest of shoal 4, a shore-attached shoal. Distribution of shoal 3 surficial sediments shows no discernable pattern, which may be attributable to the fact that only a small portion (Maryland portion) of this shoal was sampled. On shoal 1, which is an ebb tidal delta, the coarser sediments are located on the distal perimeter (seaward end) of the shoal. The textural distribution patterns of the surficial sediments relative to shoal topography are believed to be a result of the local shelf hydraulic regime (Duane *et al.*, 1972; Field, 1976,1980; Swift and Field, 1981; McBride and Moslow, 1991).

The textural character of the modern shelf deposits varies from shoal to shoal. The detached shoals are characterized by coarser sand when compared to the shore-attached shoals. Medium to coarse sand is associated with detached shoals 3 and 9. The gravel found around shoal 3 is believed to be reworked from underlying depositional units or eroding headlands found along Bethany Beach. Cores 8-2 and 8-5, collected to the west of shoal 3, penetrated a thick sequence of poorly sorted sediments with a high gravel content. Shoal 2, which is classified as a nearshore shoal, is composed primarily of moderately sorted, fine to medium sand. The composite mean and sorting for sands above -13.7 meters NGVD are 1.76 phi and 1.01 phi, respectively (Anders and Hansen, 1990). The modern shelf deposits of shore-attached shoals 1, 4, 5, 6 and 7 also are predominately fine sands.

SHALLOW NEARSHORE STRATIGRAPHY

Seismic records show that the Q2 depositional unit lies immediately beneath the A1 horizon throughout much of the study area. This unit often is exposed to the sea floor in the trough areas. This interpretation concurs with the general shallow stratigraphic framework of Toscano *et.al.* (1989).

Radiocarbon dates of organic-rich sediments recovered from several cores (cores 1-3, 3-12 and 8-3; see Appendix I, Table VII) indicate the Q2 unit sampled in the study area is Pleistocene in age. The dates are older than 29 ka and, therefore, are treated as minima for the dated material. The age estimate of the Q2 sediments based on acid amino racemization dating technique is 80 to 128 ka (Toscano *et al.*, 1989; Toscano, 1991; Toscano and York, 1992).

Mid-Atlantic chronologies based on aminostratigraphic techniques have been developed for several genera of mollusk including *Mulinia*, *Mercenaria*, and *Crassostrea*. More recent work has further defined a consistent chronology for the Q2 unit based on the species *Mulinia lateralis* (Toscano *et al.*, 1989, Toscano and York, 1992; York *et al.*, 1989). Therefore, these three genera were targeted for amino acid racemization analyses because they yield the most applicable ratios for relative age determination (Wehmiller, oral com.). A few specimens of *M. lateralis* were collected from several cores (cores 2-8 and 2-27). The shells were single valves and often fragmented suggesting they were transported or reworked, and therefore, were not analyzed. Interestingly, no *in situ* lenses of *Mulinia lateralis* were found in any of the cores examined in this study.

The Q2 sediments sampled in the vicinity of shoal 3 appear to be coarser than Q2 sediment in other parts of the study area. Most the cores penetrated poorly sorted medium sands with gravel below the projected A1 horizon. There are several possible explanation for these coarser sediments:

(1) The coarser sediments may represent a facies change in the Q2 unit. Toscano *et al.* (1989) reported a lower (basal) sand facies within the Q2 unit, interpreted to be an early oxygen-isotope stage 5 (5e:128 - 120 ka) transgressive sequence. Toscano (1991) hypothesized this sandy facies represents trailing edge shelf sand ridges correlative to the stage 5e barrier islands (including Ironshire Formation and Bethany Paralic Unit) deposited at the peak interglacial sea level. The lower Q2 facies is stratigraphically above the M2 horizon, which becomes increasingly shallow in a northwesterly direction; therefore, lower Q2 unit sediments are more likely to be penetrated by the vibracores collected in the northern part of the study area.

(2) The coarser Q2 sediments may reflect a localized facies change. The sandy Q2 unit beneath shoal 3 may represent a remnant open-shelf shoal similar to the one identified by Toscano *et al.* (1989).

Overlying the Q2 unit, the Q4 depositional unit is found to be fairly extensive, but restricted primarily to the nearshore zone (landward of the 10 meter isobath). A Carbon-14 date of 5737 +/-70 yr B.P. (5730-yr ½ life) was obtained from a peat sample at -14.32 meters NGVD from core 4-31 and is consistent with the sea level curve for the Delmarva coast (Belknap and Kraft, 1977). The Q4 deposits are interpreted to be leading-edge paralic sediments (lagoonal, fringing marsh) and associated with network of paleochannels thought to be extensions of Roy and Dirickson Creeks (Plate 4). It is uncertain whether or not these paleochannels are fluvial in origin. Sediment sequences similar to the Q3 fluvial sands and muds described by Toscano *et al.* (1989) were not found in any of the shoal 4 vibracores that penetrated paleochannel fill .

Additional evidence suggests that other Q4 paralic deposits exist beneath the shoreface along Fenwick Island. These paralic deposits are associated with several previously mapped paleochannels. Field's (1976) paleochannels 5 and 6, which were mapped offshore of south Fenwick Island, may represent early Holocene extensions of Greys Creek (Plate 4). Orientation and geometry of the paleochannels and their relative position to other offshore channels (mapped by Field 1976, and Toscano *et al.*, 1989) suggest they were part of a tributary system of the ancestral St. Martin River. The confluences of the tributaries with the St. Martin River are located to the southeast.

Most of the paleochannels are fairly shallow when compared to the ancestral channels of Indian River and Love/Herring Creeks, mapped along Delaware's Atlantic coast (Belknap and Kraft, 1985). Thalweg depths of these Delaware paleochannels exceed 40 meters within 5 kilometers of the present shoreline. The deeply incised channels are a result of headward erosion stemming away from the Delaware River. During Wisconsin time, the Delaware River had a much lower base level due to increased discharge of glacial meltwater (Chrzastowski, 1986). Conversely, gradients of Greys Creek and Roy Creek were less severe since they flowed southeast across a more gently sloping shelf. As a result, these tributaries generally had shallower thalweg depths and broader channels. Maximum depths of the paleochannels within the study area are -26 meters NGVD.

As the Holocene transgression continued, estuarine sediments (Q4 deposits) accumulated in the channels and along channel margins. Back-barrier bays similar to the present Isle of Wight and Assawoman Bays may have formed. Continued transgression to present sea levels eventually exposed the Q4 deposits to shoreface erosion.

If sea level continues to rise at the present rate, shoreface erosion is expected to scour much of the early Holocene sediments except for those in the deeper paleochannels (Belknap and Kraft, 1985) or capped by modern shoal sands. Toscano *et al.*, (1989) found no evidence of widespread leading edge Holocene lithosomes between 5 and 13 kilometers from shore, except for those preserved as fill in paleochannels. They attributed this lack of preserved leading edge Holocene deposits to the slowing rate of sea level rise between 7 ka and 2 ka. The slowed rate resulted in deeper shoreface scour and removal of the back barrier deposits.

SAND AND GRAVEL RESOURCE POTENTIAL

The vibracore and seismic data presented in this study were collected to assess potential sand resources for beach fill for Ocean City, Maryland. Specific criteria based on the native beach material were used to determine whether sand deposits were suitable. The following discussion focuses on the assessment of sand deposits in terms of their suitability for beach fill.

Although the Q2 sediments are composed primarily of sand, the sands are often interbedded with muds. Consequently, the Pleistocene (Q2) unit lacks potential for beach nourishment material, unless relict sand bodies such as the one described by Toscano *et al.* (1989) are located and quantified. Furthermore, relict sand bodies need to be near the surface; otherwise, excavating sand (and gravel) from such a source may be impractical.

The shoal sediments consist of coarse to fine sand with little or no mud content, constituting the best source for relatively clean sand. Of the shoals examined, shore-attached shoals contain the least amount of suitable sand. Seismic data for two shoals (shoals 4 and 5 in particular) show a thin veneer of modern sands overlaying the thick sequence of early Holocene and Pleistocene muds. Excavating the sand deposits would be difficult without disturbing the muds underneath.

Nearshore (detached) shoals offer better potential because they are more likely to contain thicker sequences of coarser-grained sediments. Studies of shoals suggest shoals maintain an optimum crest height as sea level rises (Duane *et al.*, 1972). This implies the shoal volume increases during transgression, with shoal sand deposits gradually becoming thicker in cross-section. Data from this study further suggest that, during the growth process, sediment texture coarsens upward in the sediment column. Many of the cores collected from shoal 9 contained Q5 sands that coarsen upward. Along shoal 3, more cores contained coarsening upward sequences than fining upward sequences. Gravel contents also increased upward in many of the shoal 3 cores.

Gravel is generally not a prominent component of the sediments examined; although several cores did contain relatively thick units of sediment having significant gravel contents. Vibracores 8-1, 8-2, and 8-5 penetrated thick units of gravelly sediments several meters below the sea floor. It is not known how extensive the gravelly sediments are or if they represent fluvial deposits. The associated iron-staining of these particular deposits suggests they are fluvial in origin. However, the observed iron-staining could also be a result of oxidation during extended subaerial exposure during the last low sea stand (Belknap and Kraft, 1977).

Dredging Activities Associated with the Ocean City Beach Replenishment Project

Suitability of the nine shoals for beach fill for the Ocean City Beach Replenishment Project are detailed in several documents (U.S.Army Corps, 1988, 1989a, 1989b; Anders and Hansen, 1990). Methodologies used to determine "suitability of sand for beach fill" are explained in the Shore Protection Manual (U.S. Army Corps, 1984). Textural properties, such as composite graphic mean (Folk) and sorting (Inman) of the potential borrow sediments were compared to the native beach sand to determine an overfill factor (R_A) using an overfill criteria developed by James (1975). The overfill factor takes into account the portion of borrow material expected to remain on the beach after equilibrium is achieved. High overfill factors indicate the borrow material would not be stable on the native beach; therefore, a larger volume of borrow material would be required on the beach in order to meet the project specifications. Composite graphic mean and sorting for the Ocean City beach were determined to be 1.84 Φ and 1.22 Φ, respectively (Anders, *et al.*, 1987; Anders and Hansen, 1990). Thus, sand most suitable for beach fill (i.e., having low overfill factors) should have a mean grain size coarser than 1.84 Φ and have a sorting value less than 1.22 Φ.

Based primarily on textural characteristics, shoals 2, 3 and 9 were selected by COE as borrow areas for beach nourishment. Shoals 2 and 3 were dredged for sand during Phases I and II. These two shoals were utilized first because they were closest to the project area (i.e., Ocean City beach), a significant cost consideration. Shoal 9, located between 4 and 5 kilometers offshore (Figure 5), has been designated as the borrow area for future (periodic and storm maintenance) dredging. Analyses of vibracores taken from shoal 9 indicate that the most suitable sand for beach fill is limited to the western flank. Estimates indicate approximately 4.5

million cubic meters (5.9 million yd^3) of suitable sand are available to a depth of -16.8 meters (NGVD) in shoal 9 (U.S. Army Corps of Engineers, 1993).

Borrow Area 2

Shoal 2, located about 3.7 kilometers offshore of south Ocean City, is an elongated, linear shoal having three distinct crests defined by the 10 meter isobath (Figure 5). Based on vibracore data, the most suitable sand for beach fill was located on the landward flank along the southern crest. Dredging was limited to this area, the boundaries of which are shown in Figure 16. The designated dredging area contained an estimated 2.69 million cubic meters (3.52 million yd^3) of medium to fine sand (R_A = 1.37) to a depth of -15.24 meters (NGVD) (Anders and Hansen, 1990). Approximately 2.87 million cubic meters of sand (3.76 million yd^3) was extracted from this borrow area for beach fill during the construction of Phases I and II, essentially exhausting the suitable sand resource within the dredging area.

Dredging for Phase I (state contract) was restricted to the reduced sub-area within borrow area 2. For Phase II (Federal contract) the borrow area limits were expanded somewhat to include areas outside the reduced sub-area. Dredging during both phases was accomplished by cutterhead dredge and the sand was pumped directly to the project area via submerged pipeline. Although this method generally minimizes volume losses, comparison of the volume cut from the borrow area (calculated from bathymetric changes) to the total material actually placed on the beach (total of 2.295 million m^3) indicates a 19% volume loss during dredging. This loss is attributed to the large amount of fine-grained material contained in the borrow material.

Figure 18 illustrates the pre- and post-dredging bathymetry of borrow area 2 (shoal 2). Sections of the shoal, as much as 7.5 meters thick, were removed, with some areas excavated below the project limit of -15.2 meters. This limit was based on the depth of the average shelf surrounding the shoal and usually coincided with the lower boundary of the shoal. However, the A1 horizon, which represents the ravinement surface separating the modern shoal sands from the underlying older, fine-grained material (Q2 deposits), is mapped at a shallower depth, -13 to -14 meters. A cross-section of the dredged area shows the relationship of the A1 horizon with the post-dredging surface (Figure 19). Fine-grained Q2 sediments were excavated along with the sand during the dredging process.

Borrow Area 3

Shoal 3, located on the Maryland/Delaware State line (Figure 5), contained the most suitable sand for the replenishment project. The COE estimated that approximately 4.34 million cubic meters (5.68 million yd^3) of medium to coarse sand (composite mean and sorting values of 1.50 Φ and 1.20 Φ, respectively (Anders and Hansen, 1990)), having an overfill factor of 1.0, were available in the Maryland portion of shoal 3. During Phases I and II, approximately 2.22 million cubic meters (2.9 million yd^3) of sand were excavated from the sub-areas I and II (Figure

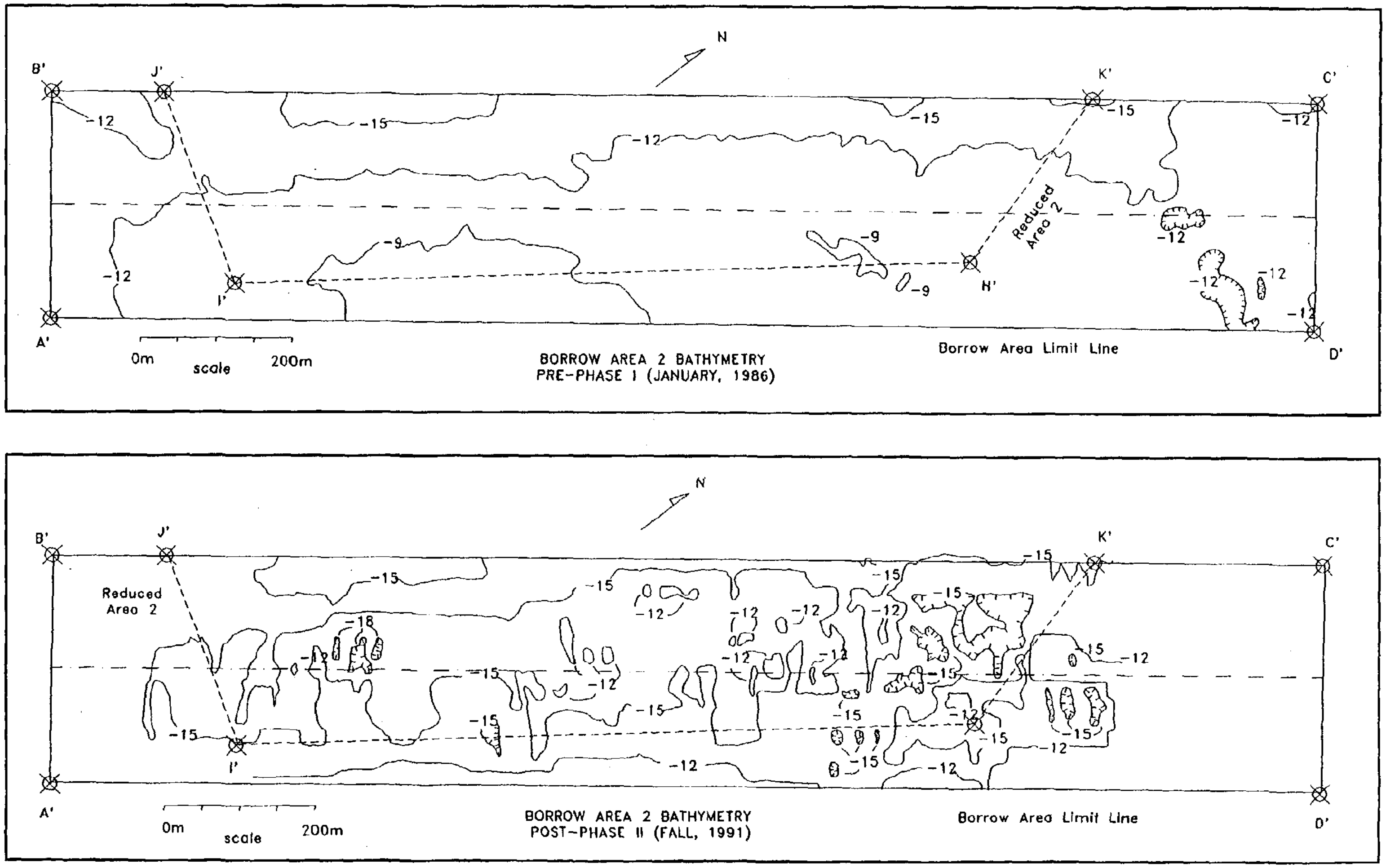


Figure 18. Pre- and post-dredging bathymetry of borrow area 2. Location of the cross-section shown in Figure 19 is indicated by dashed-dot line bisecting the borrow area.

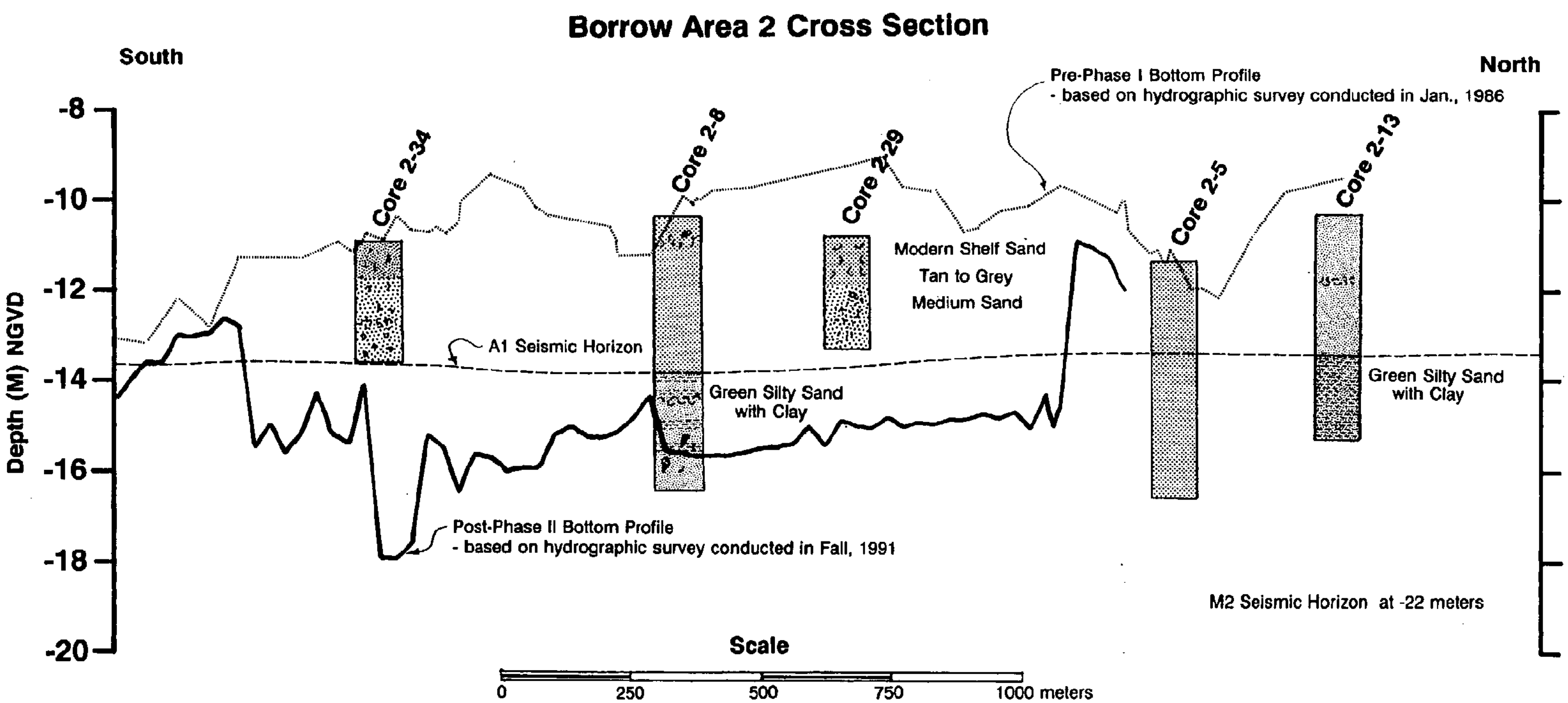


Figure 19. Cross-section of borrow area 2 illustrating pre- and post-dredging surfaces relative to mapped seismic horizon (A1) and lithologic changes.

20—sub-area boundaries indicated by solid line), essentially removing the top of the shoal. The pre- and post-dredging bathymetries of the borrow area are illustrated in Figure 20. Cross-sectional changes in depth along the axis of the shoal (Figure 21) reveal that more than 6 meters of sand were removed, with dredging extending below the projected A1 horizon. However, core lithologies indicate the Q2/Q1 unit beneath shoal 3 consists predominately of medium sand.

A hopper dredge was used to extract the sand from shoal 3 during both phases of the project. Normally, handling losses from this method are usually higher than those associated with the cutterhead method. Comparison of the volume of shoal 3 sand actually placed on the beach (2.13 million m^3) to volume cut from the shoal indicates approximately 5% of the sand was lost during dredging. This relatively low loss (compared to the 19% loss for shoal 2 using the cutterhead) is attributed to the sediment containing very little fine-grained material. Usually, fine-grained material is selectively washed away during the handling of the material by the hopper dredge, resulting in higher losses.

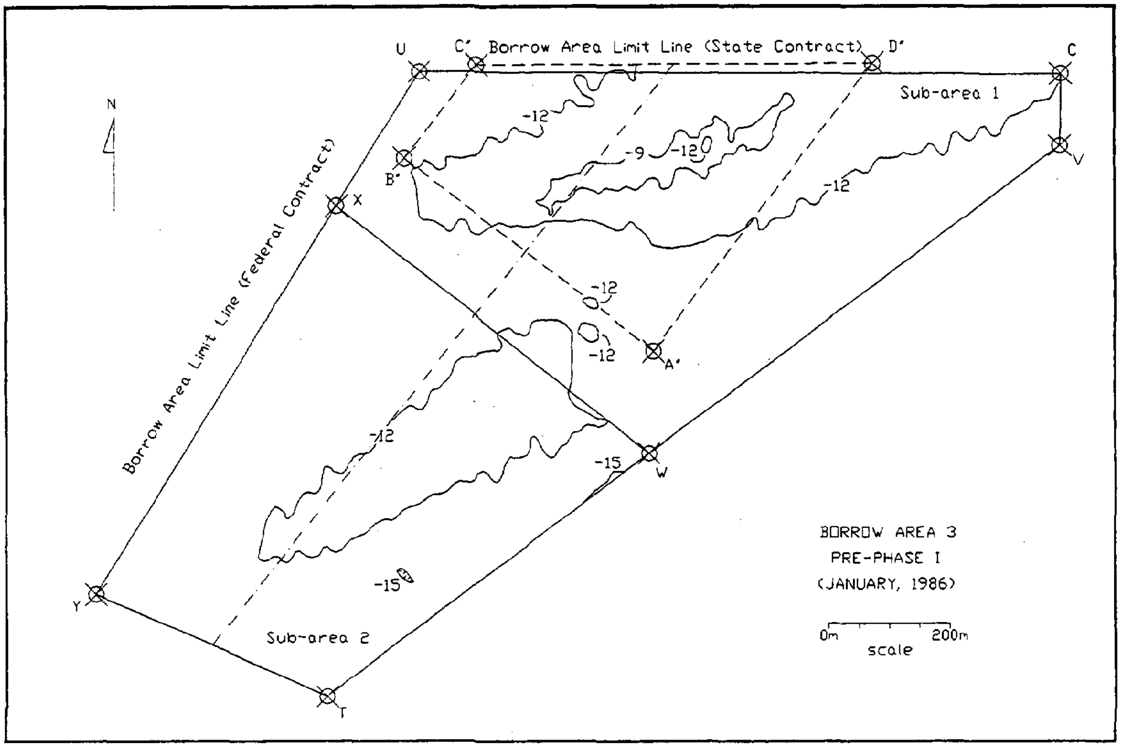
The post-Phase II bathymetry indicated approximately 2.19 million cubic meters (2.87 million yd^3) remained within shoal 3 borrow limits (sub-areas I and II). An additional 107,932 cubic meters of medium to fine sand were available in sub-area III (extreme southwest end of borrow area). The remaining sediment in the three sub-areas was excavated and placed on the Ocean City beach to repair damage from a series of severe storms that bludgeoned the Maryland coast during the winter of 1991-92. The COE has determined that approximately 380,000 cubic meters (500,000 yd^3) of suitable materials are left in borrow area 3 (above the project limit of -15.24 meter NGVD) (Jim Snyder, Baltimore District Army Corps, oral com.).

CONCLUSIONS AND SUMMARY

Data presented in this report support the late Quaternary stratigraphy outlined by Toscano *et al.* (1989). Although the limited extent of the study area precluded regional extrapolation of some of the trends seen in the data, the findings offer additional information regarding the late Quaternary history of the nearshore area and insights into identifying potential sources of sand and gravel.

At least three distinct depositional units (Pleistocene Q2 unit, late Holocene transgressive Q4 unit, and modern Q5 shelf sand) can be identified in the upper 25 meters of the nearshore shelf off Ocean City. Pleistocene sediments are exposed along much of the sea floor and lie directly beneath the modern shoal deposits. The Pleistocene deposits are characterized by several facies, from coarse sands to interbedded muds and fine sand. Textured data from the vibracores suggest the Pleistocene sediments become coarser northward. This coarsening trend would agree with the stratigraphic studies along Delaware coasts that describe the underlying Pleistocene units as sandy and gravelly (Belknap and Kraft, 1985).

Further study is needed to confirm the age of the Pleistocene unit described in this report.



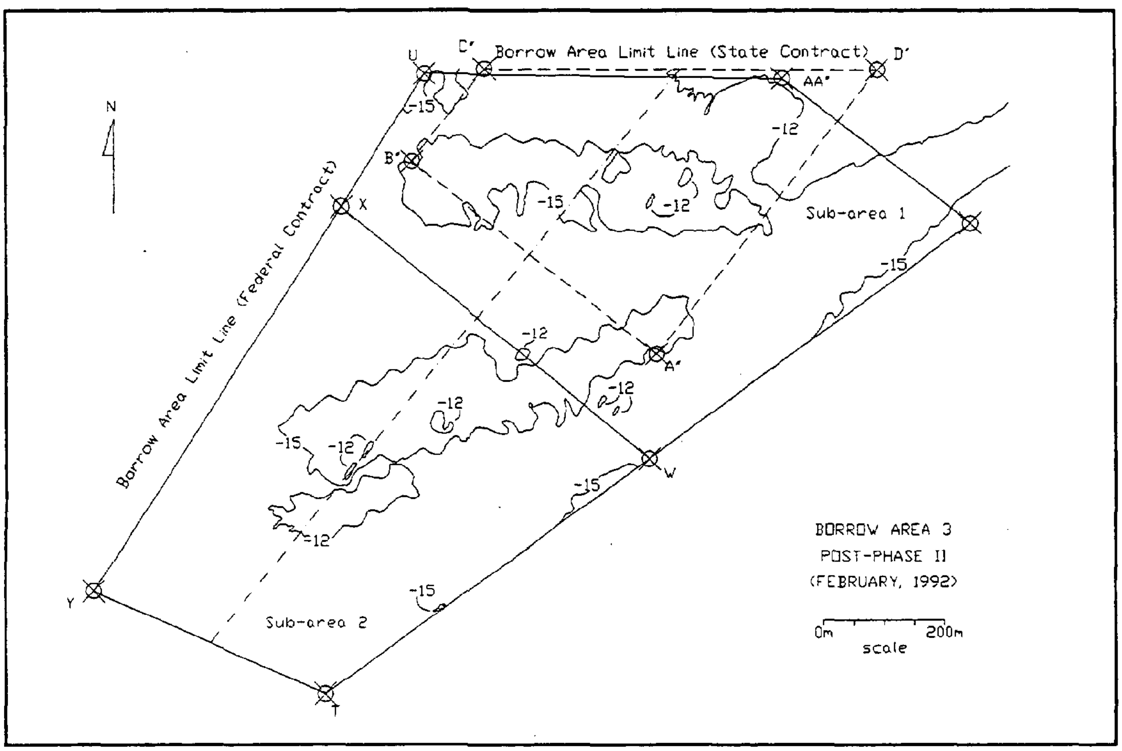


Figure 20. Pre- and post-dredging bathymetry for borrow area 3. Location of the cross-section shown in Figure 21 is indicated by dashed-dot line bisecting the borrow area.

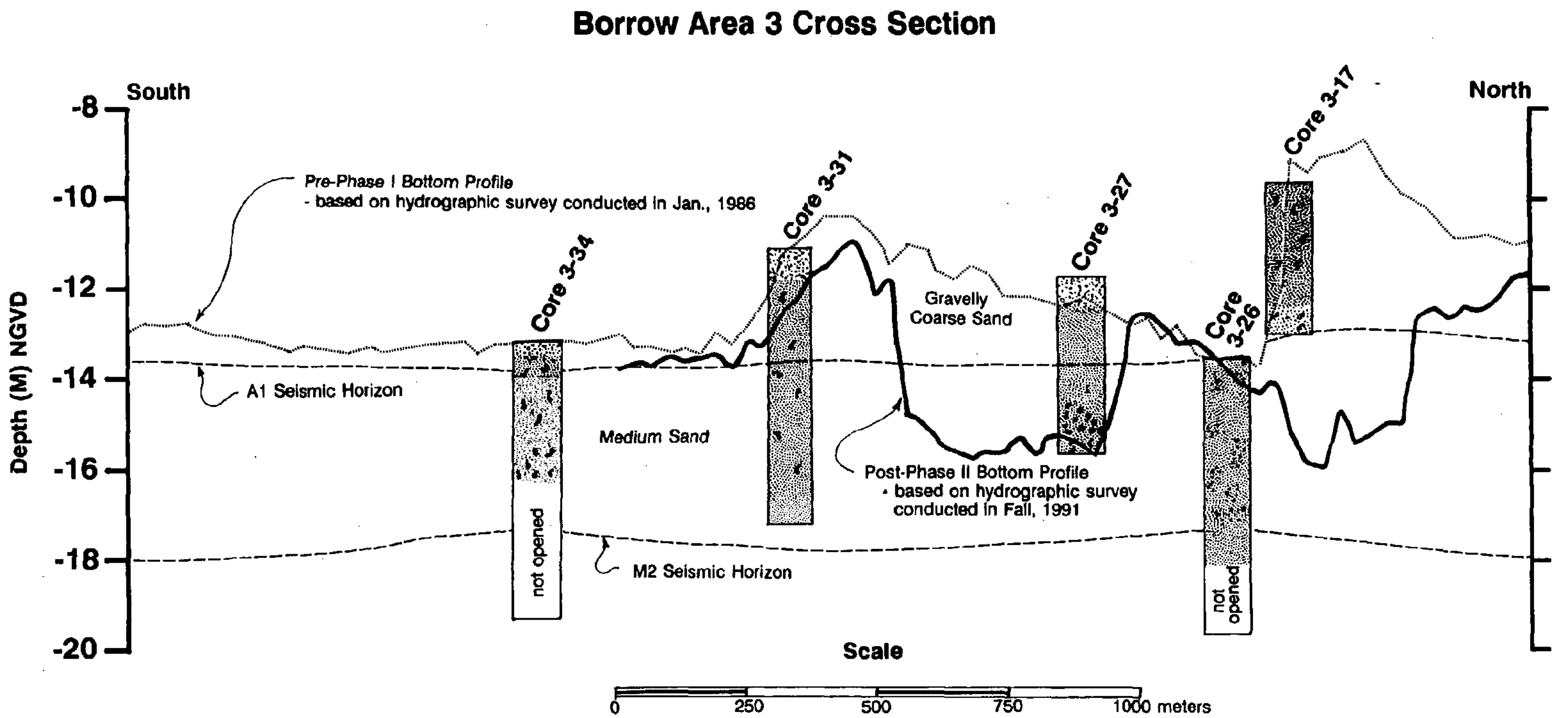


Figure 21. Cross-section of borrow area 3 illustrating pre- and post-dredging surfaces relative to A1 horizon and lithologic changes.

Seismic and lithological data provide evidence for the existence of early Holocene lagoonal (Q4) deposits. These Q4 deposits exist as fill within shallow paleochannels incised into the underlying Pleistocene unit (Q2). The Q4 deposits are restricted primarily in the shoreface zone. Much of the early Holocene depositional unit is presently subjected to shoreface erosion. With continued sea level rise, most of these deposits are expected to be removed except for those preserved beneath the shoals or in the deeper portions of the paleochannels.

Geometry and orientation of the paleochannels associated with the early Holocene deposits and relationship to offshore paleochannels suggest the channels are extensions of Roy Creek, and possibly Dirickson Creek, which presently flow into Assawoman and Little Assawoman Bays. At one time, these creeks were tributaries to the St. Martin River System which drained to the southeast. It is postulated that ancestral extensions of Greys Neck and St. Martin Neck formed the interfluves between Roy Creek, Greys Creek, and St. Martin River, respectively, during the early Holocene (Plate 4).

The northern study area is located within the paleo-interfluve between the ancestral Roy and Dirickson Creeks, both of which flowed to the southeast, and the ancestral Miller Creek which flowed north. Miller Creek presently flows into northern Little Assawoman Bay in Delaware. The southernmost tributary to the ancestral Delaware River mapped by Belknap and Kraft (1985) may correspond to Miller Creek. The reconstructed paleodrainage for the Delmarva shelf shows this paleo-interfluve to be the drainage divide separating Delaware River system to the north from the St. Martin River system, and perhaps the Susquehanna River system, to the south (Figure 22). Thus, the Wisconsin drainage divide was located farther north of the location proposed by Chrzastowski (1986) and White (1978).

Of several distinct depositional units mapped within the study area, modern shoal deposits represent the most viable sand source for beach fill. The quality and quantity of shoal sand varies depending on whether the shoal is detached or shore-attached. Detached shoals generally contain larger volumes of coarser sand as opposed to the shore-attached shoals. The relationship between shoal type (class) and morphological character (volume and texture of sediments) is related to processes governing the formation and evolution of the shoals.

Both geophysical and textural data show that the five shore-attached shoals (shoals 1, 4, 5, 6, and 7) contain insufficient volumes of suitable sand. These shoals were eliminated by the COE as borrow areas for beach fill. Three detached shoals (shoal 2, 3, and 9) were found to contain sufficient volumes of suitable sand and, thus, were selected as potential borrow areas. Two of these shoals were recently dredged for beach fill for the Ocean City Beach Replenishment Project. Over 7 million cubic meters of sand were excavated from shoals 2 and 3, essentially removing large portions of the shoals themselves and exhausting the borrow areas of suitable sand.

Analyses by COE indicate shoal 9 contains approximately 5 million cubic meters of sand (suitable for beach fill) and has been targeted for future maintenance replenishment at Ocean City. Approximately 8.7 million cubic yards of sand will be needed for periodic maintenance over

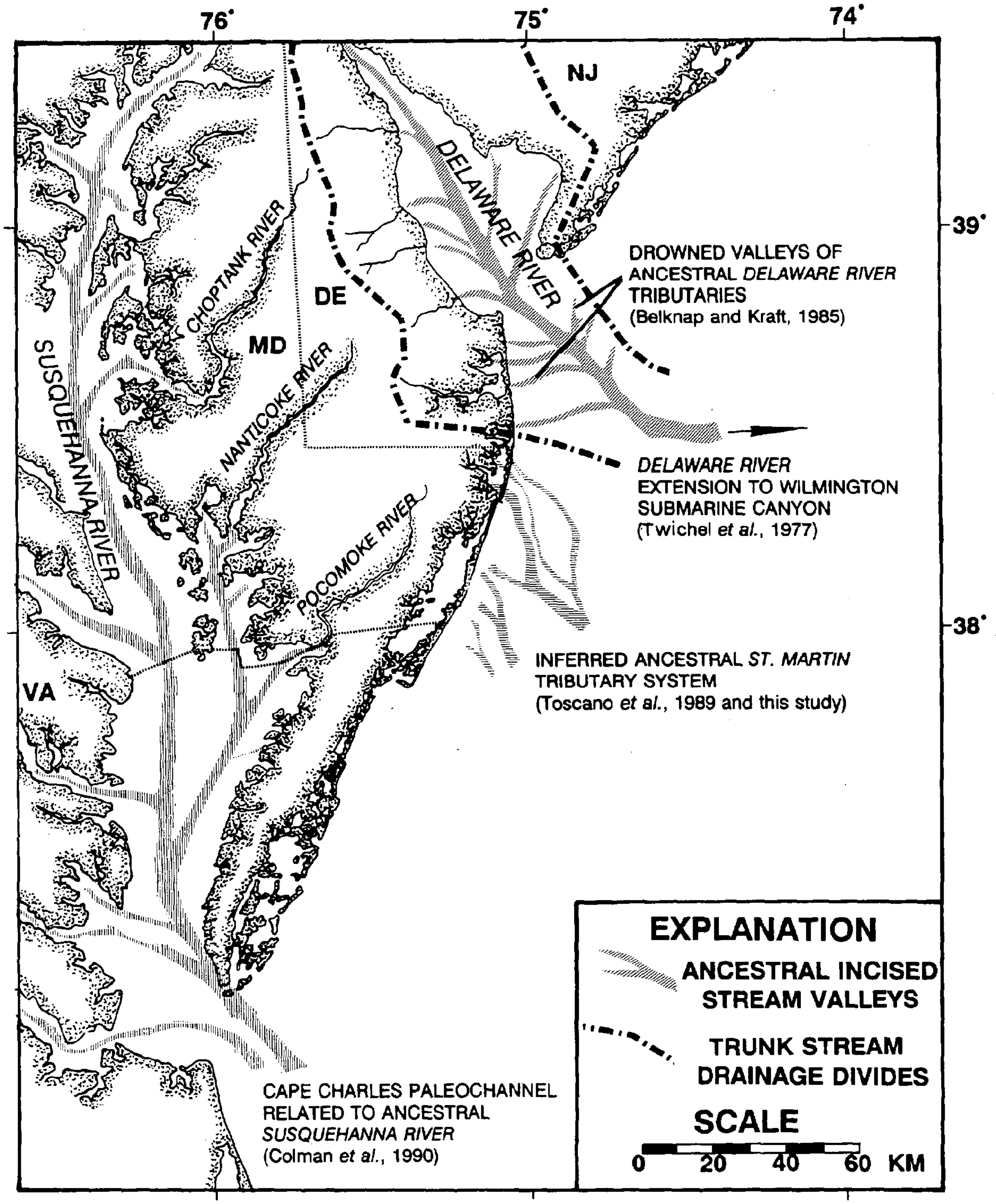


Figure 22. Wisconsin drainage system for Delmarva Atlantic shelf (modified from Chrzastowski, 1986).

the 50 year project life (U.S.Army Corps, 1989b). Other sources of suitable sand will have to be located outside the study area to meet the needs for future beach nourishment. Future investigations for suitable sand should focus on detached and offshore shoals as they offer the best potential.

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Appendix I
Vibracore Data

Table V. Summary of general vibracore information.

CORE	LATITUDE (DD MM SS.SSS)			LONGITUDE (DD MM SS.SSS)			DEPTH (M) (NGVD)	LENGTH (METERS)
1-1	38	18	44.9	75	5	38.1	-6.49	3.87
1-2	38	19	6.8	75	4	49.8	-3.93	3.85
1-3	38	19	6.0	75	5	26.2	-4.05	4.51
1-4	38	18	42.8	75	4	58.6	-6.98	3.66
1-5	38	18	57.3	75	5	8.9	-2.96	2.53
1-6	38	19	7.2	75	5	11.1	-5.46	4.00
1-7	38	18	43.8	75	4	34.1	-9.45	4.32
1-8	38	19	17.2	75	4	48.3	-7.10	5.05
1-9	38	19	7.9	75	4	54.8	-4.18	4.67
1-12	38	19	25.2	75	4	45.1	-5.43	3.35
1-16	38	19	15.6	75	4	30.9	-4.27	3.35
1-17	38	18	59.8	75	4	32.2	-2.87	3.05
2-1	38	21	58.4	75	0	54.8	-12.80	5.94
2-2	38	21	58.3	75	0	49.1	-14.33	4.33
2-3	38	21	34.7	75	1	24.9	-11.28	4.72
2-4	38	22	11.7	75	0	53.8	-13.41	5.97
2-5	38	21	19.0	75	1	31.7	-11.28	5.21
2-6	38	21	19.1	75	1	41.7	-13.41	5.64
2-7	38	21	2.3	75	1	40.3	-10.06	5.79
2-8	38	20	56.6	75	1	54.9	-10.36	6.04
2-9	38	20	57.1	75	1	54.2	-10.36	3.84
2-10	38	20	48.4	75	1	36.9	-12.50	6.10
2-11	38	20	51.2	75	1	54.4	-14.30	2.62
2-12	38	20	19.0	75	2	22.3	-12.80	6.00
2-13	38	21	27.8	75	1	25.1	-10.36	5.00
2-14	38	22	9.2	75	0	45.1	-13.99	6.10
2-15	38	22	3.7	75	0	57.4	-12.16	6.10
2-16	38	21	58.1	75	1	9.3	-11.30	6.10
2-17	38	21	48.9	75	0	50.7	-12.68	6.10
2-18	38	21	44.0	75	1	5.0	-12.34	6.10
2-19	38	21	40.7	75	0	58.6	-12.50	6.10
2-20	38	21	41.6	75	1	22.4	-14.51	6.10
2-21	38	21	36.6	75	1	12.2	-11.34	4.85
2-22	38	21	32.5	75	1	4.3	-13.99	6.04
2-23	38	21	27.7	75	1	18.8	-10.42	6.10
2-24	38	21	22.5	75	1	8.2	-12.04	6.10
2-25	38	21	25.6	75	1	35.9	-11.86	5.73
2-26	38	21	18.8	75	1	22.9	-10.58	6.16
2-27	38	21	14.4	75	1	17.3	-14.94	5.73
2-28	38	21	11.6	75	1	32.3	-13.50	3.75
2-29	38	21	7.6	75	1	46.5	-10.82	2.59

Table V (cont.). Summary of general vibracore information.

CORE	LATITUDE (DD MM SS.SSS)			LONGITUDE (DD MM SS.SSS)			DEPTH (M) (NGVD)	LENGTH (METERS)
2-30	38	20	58.4	75	1	28.2	-10.82	3.87
2-31	38	20	55.0	75	1	45.7	-10.73	3.17
2-32	38	20	41.5	75	1	42.2	-13.90	6.10
2-33	38	20	43.0	75	1	54.8	-8.69	3.23
2-34	38	20	42.1	75	2	6.5	-10.85	2.74
2-35	38	20	37.9	75	1	58.7	-10.03	3.11
2-36	38	20	35.2	75	1	52.9	-10.73	3.20
2-37	38	20	35.7	75	2	16.9	-13.69	4.79
2-38	38	20	30.2	75	2	6.2	-10.57	2.77
2-39	38	20	27.1	75	2	0.2	-11.73	6.10
2-40	38	20	32.8	75	2	26.1	-10.24	6.10
2-41	38	20	20.7	75	2	10.4	-12.16	6.10
2-42	38	20	26.7	75	2	34.5	-12.56	6.10
2-43	38	20	22.7	75	2	27.0	-11.31	6.10
2-44	38	20	11.9	75	2	6.1	-12.92	6.10
3-6	38	27	4.3	74	59	48.5	-9.75	6.68
3-7	38	26	56.4	74	59	51.2	-9.14	5.67
3-9	38	27	5.3	74	59	52.2	-10.67	3.47
3-10	38	26	48.1	74	59	59.0	-12.50	4.27
3-12	38	27	5.1	74	59	10.1	-12.50	5.67
3-13	38	27	0.7	74	59	42.5	-9.97	5.76
3-14	38	27	4.2	75	0	3.6	-12.92	6.10
3-15	38	26	56.2	75	0	0.6	-9.17	4.51
3-16	38	27	3.1	74	59	49.5	-10.67	3.35
3-17	38	26	55.1	75	0	9.0	-10.79	3.35
3-18	38	26	56.7	75	0	22.8	-13.35	6.10
3-19	38	26	48.0	75	0	7.4	-12.34	6.10
3-20	38	26	42.4	74	59	58.3	-12.98	6.10
3-21	38	27	3.2	74	59	21.9	-11.28	4.57
3-22	38	27	3.3	74	59	32.0	-11.58	3.96
3-23	38	26	55.8	74	59	38.4	-12.86	6.10
3-24	38	26	50.3	74	59	50.3	-13.41	6.10
3-25	38	26	42.1	74	59	50.4	-13.69	6.10
3-26	38	26	51.7	75	0	13.9	-11.61	6.10
3-27	38	26	40.3	75	0	15.4	-11.67	3.96
3-28	38	26	45.0	75	0	23.1	-13.84	6.10
3-29	38	26	32.3	75	0	20.6	-11.00	4.18
3-30	38	26	37.0	75	0	30.7	-13.66	6.10
3-31	38	26	29.9	75	0	30.6	-11.09	6.10
3-32	38	26	30.8	75	0	41.1	-13.44	6.10
3-33	38	26	22.4	75	0	32.7	-13.41	6.10

Table V (cont.). Summary of general vibracore information.

CORE	LATITUDE (DD MM SS.SSS)			LONGITUDE (DD MM SS.SSS)			DEPTH (M) (NGVD)	LENGTH (METERS)
3-34	38	26	17.5	75	0	44.0	-13.23	6.10
3-35	38	26	8.8	75	0	46.2	-13.53	6.10
3-36	38	26	14.7	75	0	55.8	-13.53	6.10
3-37	38	26	14.7	75	0	46.2	-12.44	6.10
3-38	38	26	0.4	75	0	52.2	-13.20	6.10
3-39	38	26	4.7	75	1	3.2	-13.50	5.36
3-40	38	26	26.9	75	0	49.7	-13.35	5.58
3-41	38	26	55.0	74	59	51.9	-9.94	3.51
4-1	38	25	6.0	75	1	37.3	-8.99	5.88
4-2	38	24	21.5	75	1	39.8	-12.80	6.06
4-3	38	24	21.8	75	2	23.8	-10.18	5.97
4-4	38	24	5.2	75	2	6.7	-9.14	5.65
4-5	38	24	12.3	75	1	47.6	-9.14	3.85
4-6	38	24	12.3	75	2	20.3	-9.14	5.46
4-7	38	23	27.3	75	2	49.2	-8.84	5.20
4-8	38	23	51.7	75	2	27.1	-9.14	4.73
4-10	38	25	23.6	75	1	25.5	-9.33	6.10
4-11	38	25	23.6	75	1	35.4	-9.57	6.10
4-12	38	25	1.7	75	1	47.5	-9.17	6.10
4-13	38	24	53.9	75	1	54.1	-9.33	4.57
4-14	38	24	44.8	75	2	3.0	-9.30	5.70
4-15	38	24	35.0	75	2	6.6	-9.44	6.10
4-16	38	24	27.8	75	2	16.2	-9.97	6.10
4-17	38	25	19.0	75	1	18.1	-13.11	6.10
4-18	38	25	29.0	75	1	27.5	-10.30	6.10
4-19	38	25	34.2	75	1	26.5	-12.80	5.00
4-20	38	25	29.1	75	1	16.2	-11.00	6.10
4-21	38	25	32.0	75	1	9.0	-11.77	6.10
4-22	38	25	41.8	75	1	19.2	-11.73	5.79
4-23	38	25	41.4	75	1	6.0	-10.76	6.10
4-24	38	25	45.5	75	1	2.4	-12.31	6.10
4-25	38	25	37.8	75	1	15.0	-10.42	6.10
4-26	38	25	51.0	75	1	13.2	-12.56	5.30
4-27	38	25	54.2	75	1	2.7	-13.17	4.91
4-28	38	24	53.6	75	1	42.8	-9.14	5.36
4-29	38	24	44.2	75	1	51.9	-8.96	4.85
4-30	38	24	19.6	75	2	10.6	-8.75	6.10
4-31	38	24	13.5	75	2	27.6	-9.57	6.15
4-32	38	24	28.7	75	2	6.9	-8.81	4.27
4-33	38	24	39.3	75	1	57.7	-9.05	4.57
4-34	38	24	47.7	75	1	56.6	-8.44	4.42

Table V (cont.). Summary of general vibracore information.

CORE	LATITUDE (DD MM SS.SSS)			LONGITUDE (DD MM SS.SSS)			DEPTH (M) (NGVD)	LENGTH (METERS)
4-35	38	25	9.6	75	1	30.3	-9.66	6.10
5-1	38	25	17.7	75	1	3.9	-9.14	5.84
5-2	38	24	38.9	75	2	42.8	-7.32	5.38
5-3	38	25	11.8	75	1	3.9	-9.75	5.87
5-4	38	24	41.9	75	2	45.2	-7.01	5.58
6-1	38	22	19.4	75	1	38.2	-8.23	4.70
6-2[1]	38	22	1.4	75	1	28.0	-10.67	5.26
6-3	38	21	15.0	75	2	57.1	-7.62	5.09
6-4	38	21	45.2	75	2	30.6	-9.45	5.95
6-5	38	21	29.0	75	2	8.4	-10.67	4.98
6-6	38	22	35.2	75	1	38.3	-8.53	4.72
6-7	38	21	42.5	75	2	16.8	-8.84	5.82
6-8	38	20	28.4	74	59	46.5	-10.45	6.10
6-9	38	20	59.2	75	3	15.4	-7.32	4.57
6-10	38	21	7.9	75	2	52.1	-6.89	6.10
6-11	38	21	17.9	75	2	40.6	-6.28	3.05
6-12	38	21	51.4	75	2	30.8	-8.02	3.05
6-13	38	21	51.4	75	2	21.9	-8.20	3.20
6-14	38	21	51.7	75	2	11.0	-7.99	2.90
6-15	38	22	1.6	75	2	3.2	-8.26	3.05
6-16	38	22	17.2	75	1	53.0	-9.57	3.66
7-1	38	19	44.9	75	2	48.3	-13.11	5.03
7-2	38	19	54.9	75	2	54.9	-9.14	5.84
7-3	38	20	19.7	75	2	33.5	-12.19	5.87
7-4	38	20	4.3	75	2	28.9	-13.11	5.34
8-1	38	26	57.4	75	1	16.7	-12.50	5.50
8-2	38	26	20.2	75	1	12.7	-11.58	5.64
8-4	38	26	35.2	75	1	19.2	-11.58	3.61
8-5	38	26	20.1	75	1	5.8	-13.72	6.20
9-1	38	24	6.1	75	0	7.9	-10.97	5.79
9-2	38	25	27.9	74	59	21.0	-8.23	4.79
9-3	38	24	40.8	74	59	41.8	-8.23	3.99
9-4	38	24	9.2	75	0	32.6	-10.79	4.11
9-5	38	24	31.9	74	59	58.0	-10.70	5.18
9-6	38	24	23.1	74	59	47.4	-10.30	4.18
9-7	38	25	3.3	74	59	37.3	-9.36	4.18
9-8	38	25	17.6	74	59	36.1	-10.58	3.35

[1] Core location coordinates reported by the COE may be incorrect; core was collected at north end of shoal 6, near core 6-1.

Table V (cont.). Summary of general vibracore information.

CORE	LATITUDE (DD MM SS.SSS)			LONGITUDE (DD MM SS.SSS)			DEPTH (M) (NGVD)	LENGTH (METERS)
9-9	38	25	14.9	74	59	22.9	-10.64	6.10
9-10	38	25	41.5	74	59	12.0	-9.48	3.96

Table VI. Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
1-1	- 6.49	-8.69	0.00	2.20	2.90	0.63			S	light tan gray medium sand with occasional silt, shell fragments and heavy minerals
1-1	- 8.61	-9.40	2.12	2.91						dark brown peat
1-1	- 9.40	-9.99	2.91	3.50						dark gray clay
1-1	- 9.99	-10.36	3.50	3.87						gray sandy mud
1-2	- 3.93	-7.78	0.00	3.85	2.35	0.46		0.10	S	tan medium sand with shells
1-3	- 4.05	-5.16	0.00	1.11	1.96	0.68		1.88	S	light tan sand with shells
1-3	-5.16	-5.52	1.11	1.47	1.35	0.90	1.97	1.88	S	medium to coarse sand with shell fragments
1-3	-5.52	-6.03	1.47	1.98						dark gray sandy mud
1-3	-6.03	-7.16	1.98	3.11	2.31	0.80		3.23	S	brown to gray mottled sand; some Fe staining
1-3	-7.16	-7.86	3.11	3.81	2.33	1.72			S	gray brown medium sand; some Fe staining
1-3	-7.86	-8.56	3.81	4.51						peat, ^{14}C date- 31,190 ±1330 yr. B.P.
1-4	-6.98	-7.79	0.00	0.81	2.32	0.68			S	light tan clean sand
1-4	-7.79	-9.73	0.81	2.75	0.87	0.72	1.87		S	coarse sand
1-4	-9.73	-10.11	2.75	3.13	1.54	0.45			S	medium sand
1-4	-10.11	-10.64	3.13	3.66						dark gray to black silty clay
1-5	-2.96	-5.49	0.00	2.53	1.68	0.58	1.53		S	light tan medium to coarse clean sand with heavy minerals and shell fragments
1-6	-5.46	-5.81	0.00	0.35	0.64	1.26	11.48		gS	light tan to gray coarse to fine sand with gravel
1-6	-5.81	-8.48	0.35	3.02	1.36	0.58			S	light tan to gray coarse to fine sand with shell fragments
1-6	-8.48	-9.46	3.02	4.00	2.01	0.54			S	light tan to gray coarse to fine sand with shell fragments

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
1-7	-9.45	-10.85	0.00	1.40	2.68	0.60		2.29	S	light to medium gray, medium sand with heavy minerals
1-7	-10.85	-11.35	1.40	1.90						peaty mud
1-7	-11.35	-12.32	1.90	2.87	3.29	0.34		11.44	mS	medium gray muddy sand
1-7	-12.32	-12.95	2.87	3.50	0.91	2.31	18.68	10.55	gmS	dark gray muddy sand with gravel
1-7	-12.95	-13.77	3.50	4.32						red silty clay with coarse sand
1-8	-7.10	-7.75	0.00	0.65	1.33	0.81	5.18		gS	light tan medium to fine sand
1-8	-7.75	-12.15	0.65	5.05	1.98	0.46			S	light tan medium to fine sand with occasional shell fragments
1-9	-4.18	-4.79	0.00	0.61	0.89	1.24	11.71		gS	tan gray fine to coarse sand
1-9	-4.79	-8.85	0.61	4.67	1.59	0.58			S	tan gray fine to coarse sand with heavy minerals and occasional shells
1-12	-5.43	-7.93	0.00	2.50	2.26	0.52			S	brown gray sand
1-12	-7.93	-8.78	2.50	3.35	1.60	0.98			S	brown gray sand with gravel
1-16	-4.27	-4.54	0.00	0.27	1.34	0.53			S	gray sand
1-16	-4.54	-4.97	0.27	0.70	2.22	0.56			S	brown gray sand
1-16	-4.97	-5.22	0.70	0.95	1.62	0.52			S	light gray sand
1-16	-5.22	-7.32	0.95	3.05	2.33	0.48			S	light brown gray sand
1-16	-7.32	-7.62	3.05	3.35	0.81	1.56	14.00		gS	brown gravelly sand with shells
1-17	-2.87	-3.97	0.00	1.10	1.46	0.42			S	light gray sand
1-17	-3.97	-5.92	1.10	3.05	1.64	0.53			S	light brown gray sand with occasional shells
2-1	-12.80	-15.02	0.00	2.22	2.48	0.63	2.86	8.44	S	black muddy sand
2-1	-15.02	-16.24	2.22	3.44	1.08	0.95	2.67	2.58	S	gray sand
2-1	-16.24	-17.31	3.44	4.51	2.79	0.70		14.67	mS	gray fine sand
2-1	-17.31	-17.49	4.51	4.69	-0.08	2.08	37.16	2.47	gS	dark gray gravelly sand

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-1	-17.49	-18.74	4.69	5.94	2.74	1.23		27.67	mS	gray muddy sand
2-2	-14.33	-14.42	0.00	0.09	2.40	0.36			S	gray sand
2-2	-14.42	-15.37	0.09	1.04	2.44	0.36		1.47	S	dark gray sand
2-2	-15.37	-15.76	1.04	1.43	0.18	0.80	10.13		gS	gravelly sand
2-2	-15.76	-17.38	1.43	3.05	2.58	0.66		10.57	mS	dark gray silty sand with shells
2-2	-17.38	-17.99	3.05	3.66	2.00	0.74	1.17	2.09	S	mottled light to dark gray sand
2-2	-17.99	-18.66	3.66	4.33	2.36	0.28		2.26	S	gray sand
2-3	-11.28	-14.42	0.00	3.14	2.16	0.44			S	gray to tan sand
2-3	-14.42	-16.00	3.14	4.72	2.01	0.40			S	gray to tan sand with mud
2-4	-13.41	-15.09	0.00	1.68	2.21	0.47			S	gray sand with heavy mineral layers
2-4	-15.09	-15.39	1.68	1.98	2.58	0.30		3.74	S	dark gray sand
2-4	-15.39	-16.7	1.98	3.29	2.64	0.45		9.36	S	dark gray silty sand
2-4	-16.70	-16.92	3.29	3.51	1.52	1.24	4.04	6.01	S	silty sand with gravel
2-4	-16.92	-18.80	3.51	5.39	1.51	0.88	2.12	3.06	S	medium to coarse sand
2-4	-18.80	-19.38	5.39	5.97	-0.06	1.90	32.50	1.55	sG	gray sand grading downcore into gravel
2-5	-11.28	-16.49	0.00	5.21	1.98	0.44			S	tan to gray sand
2-6	-13.41	-14.17	0.00	0.76	1.47	0.48	1.43		S	light gray sand with heavy mineral layers
2-6	-14.17	-15.42	0.76	2.01	2.51	0.88	1.78	3.64	S	dark gray sand
2-6	-15.42	-16.70	2.01	3.29	2.38	0.82	3.00	10.66	mS	dark gray sand with mud layers
2-6	-16.70	-19.05	3.29	5.64	2.00	0.65		2.99	S	dark gray fine sand
2-7	-10.16	-10.77	0.00	0.61	1.88	0.03			S	light brown sand
2-7	-10.77	-13.88	0.61	3.72	2.01	0.32			S	light brown sand
2-7	-13.88	-13.94	3.72	3.78	1.61	0.58			S	light brown medium sand
2-7	-13.94	-14.82	3.78	4.66	2.12	0.38			S	gray fine sand
2-7	-14.82	-15.37	4.66	5.21	2.15	0.38			S	dark gray sand
2-7	-15.37	-15.95	5.21	5.79	2.50	0.30		1.78	S	dark gray to black fine sand

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-8	-10.36	-14.78	0.00	4.42	1.72	0.91	2.36	2.47	S	tan medium sand with mud and shells
2-8	-14.78	-15.91	4.42	5.55	2.49	1.02	1.87	14.01	mS	dark green sand with mud and shells
2-8	-15.91	-16.40	5.55	6.04	2.43	0.40		6.06	S	fine sand
2-9	-10.36	-14.20	0.00	3.84	1.19	0.48			S	medium to coarse sand with shells
2-10	-12.50	-15.37	0.00	2.87	2.43	0.34	0.00	2.13	S	gray sand with mud layers and wood
2-10	-15.37	-17.22	2.87	4.72	3.14	1.04		22.49	mS	dark gray sand grading downcore into mud
2-10	-17.22	-18.60	4.72	6.10	1.77	0.70	1.34		S	green gray sand with gravel
2-11	-14.30	-15.00	0.00	0.70	1.14	0.50			S	medium to coarse sand
2-11	-10.15	-10.64	0.70	1.19	0.09	1.25	23.62		gS	gravelly sand
2-11	-10.64	-12.07	1.19	2.62	1.90	0.87	1.04		S	fine to medium sand
2-12	-12.80	-13.10	0.00	0.30	0.87	1.04	7.06	2.01	gS	dark green medium to coarse sand
2-12	-13.10	-15.15	0.30	2.35	2.53	0.60	1.16	10.14	mS	green-gray muddy sand, fining downcore
2-12	-15.15	-16.06	2.35	3.26	2.97	1.16		40.35	mS	interbedded black sand and mud
2-12	-16.06	-18.80	3.26	6.00	2.35	0.48		3.48	S	dark green-gray fine to medium sand
2-13	-10.36	-13.35	0.00	2.99	2.15	0.44			S	tan sand with shells, fining downcore
2-13	-13.35	-14.81	2.99	4.45	2.36	0.40		1.33	S	gray sand with mud pockets and shells
2-13	-14.81	-14.96	4.45	4.60	2.57	0.33	1.30	6.67	S	silty sand
2-13	-14.96	-15.36	4.60	5.00	2.61	0.30		5.75	S	green muddy fine sand
2-14	-13.99	-14.42	0.00	0.43	2.42	0.33		1.40	S	olive-gray sand
2-14	-14.42	-14.48	0.43	0.49	4.32	2.80		35.80	mS	gray muddy sand
2-14	-14.48	-14.81	0.49	0.82	2.37	0.49	2.20	2.10	S	gray silty sand
2-14	-14.81	-15.51	0.82	1.52	2.37	0.45		1.00	S	olive-gray silty sand
2-14	-15.51	-20.09	1.52	6.10						not opened

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-15	-12.16	-15.23	0.00	3.07	2.35	0.42		1.00	S	dark gray silty sand
2-15	-15.23	-18.26	3.07	6.10						not opened
2-16	-11.30	-11.85	0.00	0.55	2.36	0.42		1.00	S	dark gray silty sand
2-16	-11.85	-14.99	0.55	3.69	2.29	0.46		1.10	S	dark gray silty sand
2-16	-14.99	-15.87	3.69	4.57	2.02	0.61		2.20	S	dark gray silty sand with shells
2-16	-15.87	-17.40	4.57	6.10						not opened
2-17	-12.68	-14.02	0.00	1.34	2.36	0.34		1.00	S	dark gray silty sand
2-17	-14.02	-15.73	1.34	3.05	2.34	0.39		1.00	S	dark gray silty sand
2-17	-15.73	-18.78	3.05	6.10						not opened
2-18	-12.34	-14.08	0.00	1.74	2.19	0.52			S	gray silty sand with shells
2-18	-14.08	-14.20	1.74	1.86				72.20	M	dark gray sandy mud
2-18	-14.20	-14.41	1.86	2.07	1.28	1.05	3.20		S	dark gray muddy sand with shells
2-18	-14.41	-15.39	2.07	3.05	2.49	0.29		4.50	S	dark gray silty sand with shells
2-18	-15.39	-18.44	3.05	6.10						not opened
2-19	-12.50	-13.11	0.00	0.61	2.13	0.53			S	olive-gray silty sand
2-19	-13.11	-13.38	0.61	0.88	2.38	0.32		1.75	S	dark gray silty sand
2-19	-13.38	-15.55	0.88	3.05	2.16	0.49			S	dark gray silty sand with shell frag
2-19	-15.55	-18.60	3.05	6.10						not opened
2-20	-14.51	-14.81	0.00	0.30	2.40	0.41		5.00	S	dark gray muddy sand with shell frag
2-20	-14.81	-15.49	0.30	0.98	2.52	0.39		5.00	S	dark gray muddy sand with shell frag
2-20	-15.49	-16.03	0.98	1.52						not tested; silty sand
2-20	-16.03	-20.61	1.52	6.10						not opened
2-21	-11.34	-11.61	0.00	0.27						no sample
2-21	-11.61	-14.97	0.27	3.63	2.14	0.52		2.50	S	gray silty sand with shell fragments
2-21	-14.97	-15.18	3.63	3.84	1.05	1.10	3.50		S	gray medium sand with shell fragments

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-21	-15.18	-15.70	3.84	4.36	2.36	0.35	1.00	1.10	S	gray silty sand with shell fragments
2-21	-15.70	-16.19	4.36	4.85						fine silty sand; not tested
2-22	-13.99	-14.39	0.00	0.40	2.41	0.40			S	dark gray silty sand with shell fragments
2-22	-14.39	-15.45	0.40	1.46	2.41	0.40		1.00	S	dark gray silty sand with shell fragments
2-22	-15.45	-20.03	1.46	6.04						not opened
2-23	-10.42	-10.97	0.00	0.55	2.33	0.32		1.00	S	dark silty clay sand with shells
2-23	-10.97	-11.58	0.55	1.16	2.29	0.44			S	dark silty clay sand with shells
2-23	-11.58	-12.89	1.16	2.47	2.32	0.42		2.25	S	dark silty clay sand with shells
2-23	-12.89	-12.95	2.47	2.53	5.94	3.69		65.00	M	dark gray sandy mud
2-23	-12.95	-13.22	2.53	2.80	1.24	0.97	3.10	1.40	S	dark gray sand with shell fragments
2-23	-13.22	-14.53	2.80	4.11	2.13	0.42			S	gray fine sand
2-23	-14.53	-16.52	4.11	6.10	2.60	0.36		6.50	S	dark gray silty fine sand with shells
2-24	-12.04	-14.39	0.00	2.35	2.39	0.04			S	gray silty sand
2-24	-14.39	-16.12	2.35	4.08	2.33	0.40		1.30	S	gray fine sand
2-24	-16.12	-16.61	4.08	4.57						not tested; fine sand with shells
2-24	-16.61	-18.14	4.57	6.10						not opened
2-25	-11.86	-14.82	0.00	2.96	2.05	0.44			S	olive-gray fine sand with shells
2-25	-14.82	-15.46	2.96	3.60	2.69	0.29		5.30	S	dark gray fine sand with shells
2-25	-15.46	-16.07	3.60	4.21						not tested; no desciption
2-25	-16.07	-17.59	4.21	5.73						not opened
2-26	-10.58	-11.54	0.00	0.96	2.18	0.46			S	gray silty sand
2-26	-11.54	-12.23	0.96	1.65	1.97	0.57		1.00	S	light olive-gray sand
2-26	-12.23	-12.44	1.65	1.86	1.42	0.82	2.50		S	light olive-gray sand with shells

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-26	-12.44	-13.54	1.86	2.96	2.20	0.45		1.30	S	gray fine sand
2-26	-13.54	-15.24	2.96	4.66	2.30	0.43		1.10	S	dark gray fine sand
2-26	-15.24	-16.74	4.66	6.16						silty fine sand; not tested
2-27	-13.50	-14.76	0.00	1.26	2.27	0.46		1.40	S	dark gray sand with shells, coarsening downcore
2-27	-14.76	-15.02	1.26	1.52						dark olive-gray mud; 2 cm spot samples tested
2-27	-14.76	-14.78	1.26	1.28				41.89	mS	spot sample- 2 cm; 58.1% sand, 20.0% silt, 26.5% clay
2-27	-14.98	-15.00	1.48	1.50				46.42	mS	spot sample- 2 cm; 53.6% sand, 20.0% silt, 26.5% clay
2-27	-15.02	-17.30	1.52	3.80						dark gray sandy mud with shell layer, no channel sample taken
2-27	-15.12	-15.14	1.62	1.64				7.05	S	spot sample- 2 cm: 92.9% sand, 3.8% silt, 3.4% clay
2-27	-15.40	-15.42	1.90	1.92				1.04	S	spot sample- 2 cm; 99.0 % sand, 0.1 % silt, 0.9 % clay
2-27	-16.20	-16.30	2.7	2.8				5.82	S	spot sample- 10 cm; 94.2 % sand, 3.8 % silt, 2.0 % clay
2-27	-17.30	-19.23	3.80	5.73						gray fine sand with occasional mud and gravel; no channel sample
2-28	-13.50	-15.73	0.00	2.23	1.87	0.52		1.00	S	olive-gray sand with shells
2-28	-15.73	-17.25	2.23	3.75	2.08	0.45		1.05	S	gray silty sand
2-29	-10.82	-11.89	0.00	1.07	1.66	0.36			S	light gray sand with abundant shells
2-29	-11.89	-12.83	1.07	2.01	0.63	1.13	11.00		gS	gray medium sand with shells
2-29	-12.83	-13.41	2.01	2.59	0.69	1.15	12.00		gS	gray medium sand with shells
2-30	-10.82	-11.37	0.00	0.55	2.40	0.31			S	olive-gray fine sand with shells
2-30	-11.37	-14.32	0.55	3.50	2.45	0.37			S	olive-gray silty sand

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-30	-14.32	-14.63	3.50	3.81						no sample
2-31	-10.73	-11.74	0.00	1.01	1.95	0.32			S	olive-gray sand with shell fragments
2-31	-11.74	-13.41	1.01	2.68	1.79	0.39			S	olive-gray sand with shell fragments
2-31	-13.41	-13.90	2.68	3.17	1.16	0.83	8.80	1.10	gS	olive-gray sand with gravel and shells
2-32	-13.90	-15.01	0.00	1.11	2.46	0.34		1.50	S	dark gray fine sand with shell fragments
2-32	-15.01	-15.42	1.11	1.52	2.57	0.34		3.40	S	dark gray fine sand with shell fragments
2-32	-15.42	-20.00	1.52	6.10						not opened
2-33	-8.69	-8.93	0.00	0.24	1.78	0.46			S	olive-gray sand with shell fragments
2-33	-8.93	-9.36	0.24	0.67	1.69	0.46			S	olive-gray sand with shell fragments
2-33	-9.36	-10.31	0.67	1.62	1.63	0.42			S	olive-gray sand
2-33	-10.31	-10.64	1.62	1.95	0.98	0.75	4.80		S	gray sand with large shell fragments
2-33	-10.64	-11.92	1.95	3.23	1.88	0.39			S	olive-gray sand
2-34	-10.85	-11.73	0.00	0.88	1.35	0.33			S	olive-gray sand with some shell
2-34	-11.73	-13.59	0.88	2.74	0.66	0.89	8.00		gS	olive-gray coarse sand with gravel and shells
2-35	-10.03	-10.82	0.00	0.79	1.81	0.43			S	gray sand with shells
2-35	-10.82	-12.19	0.79	2.16	1.31	0.37			S	olive-gray sand with shell fragments
2-35	-12.19	-12.74	2.16	2.71	1.74	0.56			S	gray sand with some shell fragments
2-35	-12.74	-13.14	2.71	3.11						no sample
2-36	-10.73	-12.31	0.00	1.58	2.07	0.45			S	gray silty sand with shell fragments
2-36	-12.31	-13.93	1.58	3.20	1.82	0.52		1.35	S	olive-gray sand with trace shell fragments
2-37	-13.69	-13.78	0.00	0.09	1.02	0.68	6.50		gS	sand with shell fragments

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-37	-13.78	-14.51	0.09	0.82	0.85	0.95	8.00		gS	dark gray sand with shell fragments
2-37	-14.51	-14.91	0.82	1.22	1.70	1.07	6.00	1.30	gS	dark gray sand with shell and gravel
2-37	-14.91	-15.43	1.22	1.74	2.71	0.37		8.00	S	dark gray silty fine sand with shell fragments
2-37	-15.43	-18.48	1.74	4.79						not opened
2-38	-10.57	-13.22	0.00	2.65	1.94	0.33			S	brown-gray sand
2-38	-13.22	-13.34	2.65	2.77	1.66	0.45		1.40	S	olive-gray sand
2-39	-11.73	-12.07	0.00	0.34	1.99	0.45			S	olive-gray sand
2-39	-12.07	-16.30	0.34	4.57	1.92	0.49			S	olive-gray sand
2-39	-16.30	-17.83	4.57	6.10						not opened
2-40	-10.24	-11.76	0.00	1.52	2.35	0.43			S	dark gray sand
2-40	-11.76	-13.84	1.52	3.60	2.39	0.42		1.00	S	dark gray sand
2-40	-13.84	-13.93	3.60	3.69	2.33	0.79	1.50	4.50	S	dark gray silty sand
2-40	-13.93	-15.70	3.69	5.46	2.66	0.38		6.50	S	dark gray fine silty sand with trace shell
2-40	-15.70	-16.34	5.46	6.10						fine silty sand; not tested
2-41	-12.16	-12.37	0.00	0.21	1.75	0.48			S	olive-gray sand with trace shell
2-41	-12.37	-14.63	0.21	2.47	1.85	0.45			S	brown-gray sand
2-41	-14.63	-15.24	2.47	3.08	1.41	0.95	3.50		S	brown-gray sand with trace shell
2-41	-15.24	-18.26	3.08	6.10						not opened
2-42	-12.56	-13.35	0.00	0.79	2.32	0.50		4.50	S	dark gray silty sand
2-42	-13.35	-14.66	0.79	2.10	2.35	0.46		5.00	S	dark gray silty sand
2-42	-14.66	-15.61	2.10	3.05	2.17	0.55	6.00	8.00	gS	dark gray silty sand with gravel
2-42	-15.61	-18.66	3.05	6.10						not opened
2-43	-11.31	-13.66	0.00	2.35	2.46	0.35		2.20	S	dark gray silty sand with trace shells
2-43	-13.66	-15.42	2.35	4.11	2.65	0.42		8.50	S	dark gray silty sand with shells

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
2-43	-15.42	-15.88	4.11	4.57						dark gray silty sand with shells; not tested
2-43	-15.88	-17.41	4.57	6.10						not opened
2-44	-12.92	-15.82	0.00	2.90	2.31	0.41		1.50	S	dark gray silty sand with trace shells
2-44	-15.82	-15.97	2.90	3.05						dark gray clay; not tested
2-44	-15.97	-19.02	3.05	6.10						not opened
3-6	-9.75	-13.99	0.00	4.24	0.71	0.84	4.64		S	reddish-yellow medium to coarse sand with gravel
3-6	-13.99	-16.43	4.24	6.68	0.93	0.96	1.98		S	mottled reddish-yellow, medium to coarse sand with shell fragments
3-7	-9.14	-10.24	0.00	1.10						no sample
3-7	-10.24	-10.64	1.10	1.50	0.15	1.29	17.13		gS	light brown to gray medium to coarse gravelly sand
3-7	-10.64	-10.94	1.50	1.80	0.84	0.78	1.82		S	light brown to gray medium to coarse sand
3-7	-10.94	-11.34	1.80	2.20	0.84	0.82	2.79		S	light brown to gray medium to coarse sand
3-7	-11.34	-11.74	2.20	2.60	0.83	0.88	4.77		S	light brown to gray medium to coarse sand
3-7	-11.74	-14.81	2.60	5.67						see core 3-41
3-9	-10.67	-14.14	0.00	3.47	0.73	0.79	5.21		gS	tan medium to coarse sand with gravel and some mud
3-10	-12.50	-16.22	0.00	3.72	1.47	0.88	1.86	1.08	S	tan to gray sand with gravel and mud pockets
3-10	-16.22	-16.37	3.72	3.87	0.48	2.03	5.73	5.16	gS	medium sand with gravel and mud layers
3-10	-16.37	-16.77	3.87	4.27	2.15	0.51	1.35	3.36	S	interbedded tan silty sand and mud
3-12	-12.50	-12.99	0.00	0.49	1.82	0.74		2.35	S	mottled tan sand with mud, shells
3-12	-12.99	-13.19	0.49	0.69	1.73	0.61			S	tan to brown sand
3-12	-13.19	-13.55	0.69	1.05	1.70	0.84	1.97		S	tan to dark gray medium sand with shell fragments

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
3-12	-13.55	-14.56	1.05	2.06	2.43	1.04	1.36	13.29	mS	interbedded dark gray sand and silty clay with shell and gravel
3-12	-14.56	-15.75	2.06	3.25	3.01	0.79		8.03	S	mottled gray fine sand with clay pockets; ^{14}C date- 32,240 ±1520 yrs B.P.
3-12	-15.75	-17.47	3.25	4.97						dark gray mud and sand layers; not tested
3-12	-17.47	-18.17	4.97	5.67	-0.30	1.62	40.70		sG	gray sandy gravel
3-13	-9.97	-10.31	0.00	0.34	0.56	0.89	5.00		gS	brown sand with gravel
3-13	-10.31	-11.22	0.34	1.25	0.60	0.89	4.50		S	brown sand with gravel
3-13	-11.22	-12.44	1.25	2.47	0.68	0.91	4.80		S	gray brown sand with trace shell fragments
3-13	-12.44	-13.90	2.47	3.93	0.75	0.93	4.8		S	brown sand with trace shell
3-13	-12.44	-14.76	2.47	4.79	0.83	0.91	4.00		S	gray brown sand with trace shell fragments
3-13	-14.76	-15.73	4.79	5.76	0.97	0.96	2.70	1.30	S	gray brown sand with silt and shell fragments
3-14	-12.92	-14.14	0.00	1.22	1.45	0.71	1.20		S	gray brown sand with some gravel
3-14	-14.14	-14.35	1.22	1.43	1.03	0.79	3.50		S	brown sand with shell fragments
3-14	-14.35	-14.47	1.43	1.55	1.42	0.73	1.10	1.00	S	gray brown sand with trace shell fragments
3-14	-14.47	-15.24	1.55	2.32	1.47	0.75	2.00	1.20	S	gray brown sand with trace shell fragments
3-14	-15.24	-15.97	2.32	3.05						sand with silty clay layer; not tested
3-14	-15.97	-19.02	3.05	6.10						not opened
3-15	-9.17	-12.83	0.00	3.66	1.16	0.80	4.50		S	olive-gray sand with gravel
3-15	-12.83	-13.68	3.66	4.51	1.40	0.81	6.00	1.00	gS	olive silty sand
3-16	-10.67	-12.74	0.00	2.07	0.55	0.88	10.00		gS	olive silty sand with gravel
3-16	-12.74	-14.02	2.07	3.35	0.86	0.83	4.00	1.70	S	olive silty sand with trace shell

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
3-17	-9.60	-9.84	0.00	0.24	1.58	0.65	1.00	1.00	S	olive silty sand
3-17	-9.84	-12.37	0.24	2.77	1.35	0.82	4.00		S	olive silty sand with trace of shell
3-17	-12.37	-12.71	2.77	3.11	1.00	0.95	7.00		gS	olive silty sand with trace gravel and shell
3-17	-12.71	-12.95	3.11	3.35	1.04	0.90	4.00	1.00	S	olive silty sand with trace gravel and shell
3-18	-13.35	-14.51	0.00	1.16	1.48	0.77	1.50	1.10	S	olive-gray silty sand
3-18	-14.51	-15.39	1.16	2.04	1.49	0.84	3.50	1.05	S	olive-gray silty sand
3-18	-15.39	-16.70	2.04	3.35						medium sand; not tested
3-18	-16.70	-19.45	3.35	6.10						not opened
3-19	-12.34	-12.89	0.00	0.55	1.55	0.69	1.00	1.15	S	olive-gray silty sand
3-19	-12.89	-13.86	0.55	1.52	1.48	0.75	2.00	2.00	S	olive-gray sand with trace gravel and shells
3-19	-13.86	-18.44	1.52	6.10						not opened
3-20	-12.98	-13.44	0.00	0.46	1.43	0.70	1.80	1.75	S	olive silty sand
3-20	-13.44	-15.21	0.46	2.23	1.31	0.82	1.80		S	olive sand with trace shells
3-20	-15.21	-16.03	2.23	3.05	1.77	0.57		1.10	S	olive silty sand
3-20	-16.03	-19.08	3.05	6.10						not opened
3-21	-11.28	-15.49	0.00	4.21	1.08	0.60	3.00		S	olive sand with trace of shells
3-21	-15.49	-15.85	4.21	4.57						medium sand; not tested
3-22	-11.58	-13.41	0.00	1.83	1.01	0.60	8.00		gS	olive silty sand with trace shells
3-22	-13.41	-13.87	1.83	2.29	0.94	0.64	9.00		gS	olive silty sand with trace shells
3-22	-13.87	-14.05	2.29	2.47	0.99	0.67	8.50		gS	olive silty sand with trace of shells
3-22	-14.05	-14.23	2.47	2.65	0.87	0.89	11.00	1.00	gS	olive silty sand with trace of gravel and shells
3-22	-14.23	-15.54	2.65	3.96	0.87	0.90	11.00	1.00	gS	olive-gray sand with gravel
3-23	-12.86	-14.38	0.00	1.52						no sample

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
3-23	-14.38	-15.91	1.52	3.05	0.33	1.35	17.50		gS	olive-silty sand with trace shell
3-23	-15.91	-18.96	3.05	6.10						not opened
3-24	-13.40	-15.69	0.00	2.29	1.22	0.93	2.00	1.00	S	olive-gray silty sand with trace shell
3-24	-15.70	-16.46	2.29	3.05						olive-gray silty sand with shell and mud
3-24	-16.46	-19.51	3.05	6.10						not opened
3-25	-13.69	-14.64	0.00	0.95	0.98	0.89	3.00		S	olive silty sand with trace shell
3-25	-14.64	-15.24	0.95	1.55	0.94	0.78	2.00		S	olive silty sand with trace shell
3-25	-15.24	-19.79	1.55	6.10						not opened
3-26	-13.56	-17.52	0.00	3.96	1.22	0.85	5.00	1.40	gS	light brown medium sand
3-26	-17.52	-18.13	3.96	4.57						medium sand; not tested
3-26	-18.13	-19.66	4.57	6.10						not opened
3-27	-11.67	-12.34	0.00	0.67	0.60	1.40	16.00		gS	olive gravelly sand
3-27	-12.34	-13.38	0.67	1.71	1.65	0.55	1.01		S	olive-gray silty sand
3-27	-13.38	-14.81	1.71	3.14	1.58	0.62	1.10	1.00	S	olive-gray silty sand
3-27	-14.81	-15.24	3.14	3.57	1.43	0.90	5.00	5.00	gS	olive silty sand with trace gravel and shells
3-27	-15.24	-15.63	3.57	3.96						medium sand with shell and cobbles
3-28	-13.84	-14.39	0.00	0.55	1.28	0.83	2.50	1.10	S	olive-brown sand with trace shells
3-28	-14.39	-15.36	0.55	1.52	1.62	0.70	2.00	1.10	S	dark gray-brown sand with trace shells
3-28	-15.36	-19.94	1.52	6.10						not opened
3-29	-11.00	-12.77	0.00	1.77	1.18	0.82	7.00		gS	olive silty sand with trace gravel
3-29	-12.77	-13.65	1.77	2.65	1.57	0.63	1.90		S	olive silty sand
3-29	-13.65	-14.90	2.65	3.90	1.56	0.62				olive silty sand
3-29	-14.90	-15.18	3.90	4.18	1.41	0.87	2.00	1.40	S	olive silty sand with trace shells
3-30	-13.66	-15.58	0.00	1.92	1.67	0.65		1.00	S	olive-gray sand

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
3-30	-15.58	-16.71	1.92	3.05						medium sand with organic silt lenses; not tested
3-30	-16.71	-19.76	3.05	6.10						not opened
3-31	-11.09	-11.73	0.00	0.64	0.65	1.30	15.00		gS	olive-gray gravelly sand
3-31	-11.73	-13.22	0.64	2.13	1.13	0.86	5.50		gS	olive sand with trace shell
3-31	-13.22	-15.05	2.13	3.96	1.52	0.73	1.60	1.00	S	olive silty sand with trace shells
3-31	-15.05	-16.58	3.96	5.49	1.62	0.69	1.00	1.00	S	olive-gray silty sand with trace shell
3-31	-16.58	-17.19	5.49	6.10						silty sand; not tested
3-32	-13.44	-14.72	0.00	1.28	1.88	0.84	3.00	1.00	S	olive-gray to medium fine sand with trace shell
3-32	-14.72	-15.39	1.28	1.95	1.96	0.61	2.60	1.50	S	olive-gray fine sand
3-32	-15.39	-16.49	1.95	3.05						fine sand; not tested
3-32	-16.49	-19.54	3.05	6.10						not opened
3-33	-13.41	-14.69	0.00	1.28	1.51	0.67			S	olive-brown medium sand
3-33	-14.69	-15.70	1.28	2.29	1.61	0.65	1.00		S	olive-gray sand
3-33	-15.70	-16.46	2.29	3.05						olive-gray sand
3-33	-16.46	-19.51	3.05	6.10						not opened
3-34	-13.23	-13.53	0.00	0.30	0.65	1.45	15.90	1.00	gS	dark gray-brown gravelly sand with shell fragments
3-34	-13.53	-13.99	0.30	0.76	1.04	0.96	6.00		gS	dark gray-brown sand with shell fragments
3-34	-13.99	-15.58	0.76	2.35	2.12	0.44		2.30	S	olive silty sand with trace shell fragments
3-34	-15.58	-16.28	2.35	3.05						olive silty sand with trace shell fragments ; not tested
3-34	-16.28	-19.33	3.05	6.10						not opened
3-35	-13.53	-14.08	0.00	0.55	1.16	0.84	4.50		S	olive silty sand
3-35	-14.08	-14.63	0.55	1.10	1.51	0.83	3.00		S	olive-gray silty sand with trace shells
3-35	-14.63	-15.39	1.10	1.86	1.94	0.51		1.10	S	olive-gray silty sand with trace shells

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
3-35	-15.39	-16.58	1.86	3.05						medium fine sand; not tested
3-35	-16.58	-19.63	3.05	6.10						not opened
3-36	-13.53	-14.44	0.00	0.91	1.18	0.96	5.40		gS	olive silty sand with trace shell
3-36	-14.44	-15.05	0.91	1.52	1.95	0.61	1.40	2.30	S	olive-gray silty sand with trace shell
3-36	-15.05	-16.58	1.52	3.05	2.21	0.66	4.25	6.50	S	dark gray muddy sand
3-36	-16.68	-19.63	3.15	6.10						not opened
3-37	-12.44	-13.96	0.00	1.52						no recovery
3-37	-13.96	-15.49	1.52	3.05	1.51	0.68			S	olive silty sand
3-37	-15.49	-18.54	3.05	6.10						not opened
3-38	-13.20	-13.81	0.00	0.61	1.54	0.68	2.00		S	olive-gray silty sand with trace shells
3-38	-13.81	-15.43	0.61	2.23	1.72	0.60	2.30		S	olive-gray silty sand with trace shells
3-38	-15.43	-16.25	2.23	3.05						medium sand; not tested
3-38	-16.25	-19.30	3.05	6.10						not opened
3-39	-13.50	-15.27	0.00	1.77	1.97	1.04	5.50	6.80	gS	dark gray muddy sand with trace gravel
3-39	-15.27	-15.82	1.77	2.32	3.92	2.46		66.00	M	dark gray muddy fine sand
3-39	-15.82	-18.86	2.32	5.36						not opened
3-40	-13.35	-15.18	0.00	1.83	1.90	0.61	2.50	5.80	S	olive-gray silty sand with trace shell
3-40	-15.18	-15.88	1.83	2.53	1.23	1.37	12.00	3.00	gS	olive-gray silty sand with gravel
3-40	-15.88	-18.93	2.53	5.58						not opened
3-41	-9.94	-11.34	0.00	1.40	0.55	0.85	9.10		gS	olive-brown sand with trace shells
3-41	-11.34	-13.45	1.40	3.51	0.81	0.83	7.00		gS	olive-brown sand with trace shells
4-1	-8.99	-13.10	0.00	4.11	2.12	0.45			S	mottled tan to gray sand with clay layers
4-1	-13.10	-13.68	4.11	4.69	2.38	0.46		2.86	S	dark gray to green sand with clay pockets

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-1	-13.68	-13.93	4.69	4.94	0.15	2.00	30.43	2.87	sG	gravelly fine sand
4-1	-13.93	-14.87	4.94	5.88	2.33	0.48		3.58	S	dark gray to green sand with clay pockets
4-2	-12.80	-13.94	0.00	1.14	2.40	0.54			S	gray to black sand
4-2	-13.94	-14.63	1.14	1.83	2.07	1.72	10.52	14.89	gS	silty medium sand with gravel
4-2	-14.63	-14.99	1.83	2.19	3.03	1.51	3.54	46.08	mS	dark gray muddy sand
4-2	-14.99	-15.22	2.19	2.42	1.97	1.70	9.66	15.67	gmS	gray silty sand with gravel
4-2	-15.22	-16.00	2.42	3.20	2.29	0.84		8.68	S	white to tan fine sand with clay layers
4-2	-16.00	-16.41	3.20	3.61	1.89	1.46	1.18	14.32	mS	interbedded sand and thin clay layers
4-2	-16.41	-17.10	3.61	4.30	2.75	0.85		14.64	mS	dark gray silty sand with clay pockets
4-2	-17.10	-18.59	4.30	5.79	3.01	1.34	1.20	48.20	mS	abrupt change to dark gray muddy sand with clay
4-2	-18.59	-18.86	5.79	6.06	2.47	0.63		4.20	S	dark brown fine sand
4-3	-10.18	-12.80	0.00	2.62	1.69	0.50			S	tan fine to medium sand with heavy minerals
4-3	-12.80	-13.47	2.62	3.29	0.79	0.55	4.16	2.59	S	dark gray to tan sand with mud increasing with depth
4-3	-13.47	-16.15	3.29	5.97						dark gray sandy mud interbedded with muddy sand; no channel sample
4-3	-13.71	-13.72	3.53	3.54				72.76	M	spot sample 1 cm; 27.7% sand, 44.6% silt, 27.7% clay
4-3	-13.98	-13.99	3.8	3.81				31.44	mS	spot sample 1 cm; 68.6% sand, 18.8% silt, 12.6% clay
4-3	-14.69	-14.70	4.51	4.52				22.23	mS	spot sample 1 cm; 77.8% sand, 11.8% silt, 10.4% clay
4-3	-14.96	-15.00	4.78	4.82				14.62	mS	spot sample 4 cm; 85.4% sand, 6.7% silt, 8.0% clay
4-3	-15.68	-15.69	5.5	5.51				8.93	S	spot sample 1 cm; 91.1% sand, 5.0% silt, 3.9% clay

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-3	-15.93	-15.94	5.75	5.76				14.96	mS	spot sample 1 cm; 85.0% sand, 8.4% silt, 6.6% clay
4-4	-9.14	-9.44	0.00	0.30	2.24	1.24	4.06	9.45	mS	dark gray fine sand with organic mud layers
4-4	-9.44	-9.64	0.30	0.50	2.97	1.86	9.06	59.11	gM	interbedded sand and mud
4-4	-9.64	-14.79	0.50	5.65						dark gray silty clay with shell and gravel; not tested
4-5	-9.14	-9.61	0.00	0.47	1.37	2.08	22.48	9.85	mgS	dark gray to black muddy sand with gravel
4-5	-9.61	-10.79	0.47	1.65	2.43	1.29	3.65	15.20	mS	gray to gray-green fine sand with clay pockets
4-5	-10.79	-11.33	1.65	2.19	2.96	1.61	3.94	53.11	M	interbedded gray sand and dark gray mud
4-5	-11.33	-12.61	2.19	3.47	1.43	1.17	1.95	2.31	S	light gray sand with finer sand layers
4-5	-12.61	-12.99	3.47	3.85	2.54	1.32		34.90	mS	interbedded sand and organic clay
4-6	-9.14	-10.15	0.00	1.01	2.19	0.36			S	tan to brown fine sand
4-6	-10.15	-11.73	1.01	2.59	2.86	0.44		12.56	mS	gray fine sand with silty clay increasing with depth
4-6	-11.73	-14.60	2.59	5.46						interbedded gray silty clay, sand and dark clay; not tested
4-7	-8.84	-12.41	0.00	3.57	1.79	1.29	5.77	2.70	gS	yellow to tan sand with silt layers
4-7	-12.41	-14.04	3.57	5.20						interbedded brown mud and tan sand; not tested
4-8	-9.14	-9.44	0.00	0.30	1.76	0.86	2.40		S	tan sand with some gravel
4-8	-9.44	-11.06	0.30	1.92	2.22	0.56			S	light brown to gray sand
4-8	-11.06	-11.78	1.92	2.64	0.91	1.42	10.59	1.24	gS	sand with gravel
4-8	-11.78	-13.87	2.64	4.73	2.48	0.79		6.94	S	tan sand with some silty clay layers
4-10	-9.33	-11.59	0.00	2.26	2.21	0.39			S	gray-brown silty sand
4-10	-11.59	-12.71	2.26	3.38	2.24	0.39		1.10	S	gray-brown silty sand
4-10	-12.71	-15.43	3.38	6.10	2.32	0.41		2.30	S	gray to brown silty sand
4-11	-9.57	-10.36	0.00	0.79	1.73	0.46			S	gray-brown silty sand

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-11	-10.36	-12.44	0.79	2.87	2.06	0.38			S	gray silty sand
4-11	-12.44	-13.84	2.87	4.27	1.95	0.50	1.20		S	gray silty sand
4-11	-13.84	-15.03	4.27	5.46	1.65	0.61		1.30	S	gray silty sand
4-11	-15.03	-15.67	5.46	6.10	2.90	1.08		16.00	mS	dark gray muddy sand
4-12	-9.17	-10.79	0.00	1.62	1.77	0.46	1.00		S	gray brown silty sand
4-12	-10.79	-12.95	1.62	3.78	2.24	0.31		1.40	S	gray silty sand
4-12	-12.95	-13.44	3.78	4.27	2.57	0.49		6.00	S	dark gray silty sand
4-12	-13.44	-14.44	4.27	5.27	2.15	0.47		2.20	S	light gray silty sand
4-12	-14.44	-14.90	5.27	5.73	1.11	1.36	5.00	7.00	gS	gray silty sand
4-12	-14.90	-15.27	5.73	6.10	2.43	0.38		4.00	S	dark gray silty sand
4-13	-9.33	-11.43	0.00	2.10	1.85	0.43			S	gray-brown sand with trace shell
4-13	-11.43	-11.80	2.10	2.47	1.58	0.68	3.00	1.00	S	gray-brown sand with trace shell
4-13	-11.80	-12.38	2.47	3.05	2.22	0.43		2.50	S	gray silty sand with trace shell
4-13	-12.38	-12.56	3.05	3.23	2.05	0.90	4.50	9.00	mS	dark gray silty sand with shell and gravel
4-13	-12.56	-13.02	3.23	3.69	3.36	0.68	2.50	17.00	mS	dark gray muddy sand
4-13	-13.02	-13.20	3.69	3.87	2.21	2.26	12.00	20.00	gmS	dark gray muddy sand with gravel
4-13	-13.20	-13.51	3.87	4.18	2.49	0.40		7.50	S	gray silty sand
4-13	-13.51	-13.69	4.18	4.36	3.57	1.58		33.00	Ms	gray muddy sand
4-13	-13.69	-13.90	4.36	4.57						no sample
4-14	-9.30	-9.79	0.00	0.49	1.74	0.44			S	gray-brown silty sand
4-14	-9.79	-12.81	0.49	3.51	1.35	0.40			S	gray-brown sand
4-14	-12.81	-13.05	3.51	3.75	1.39	0.55			S	gray-brown sand
4-14	-13.05	-14.42	3.75	5.12	3.44	2.53		31.00	mS	dark gray muddy sand with trace shell
4-14	-14.42	-15.00	5.12	5.70	1.38	0.40		1.60	S	gray sand
4-15	-9.44	-10.84	0.00	1.40	1.55	0.38			S	gray-brown sand
4-15	-10.84	-12.49	1.40	3.05	5.16	2.52		54.50	M	dark gray sandy mud

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-15	-12.49	-15.54	3.05	6.10						not opened
4-16	-9.97	-10.76	0.00	0.79	1.46	0.45			S	gray-brown sand
4-16	-10.76	-11.34	0.79	1.37	1.14	0.36			S	gray-brown sand
4-16	-11.34	-12.59	1.37	2.62	0.57	0.66	9.00	1.80	gS	gray-brown sand with gravel and shell
4-16	-12.59	-13.02	2.62	3.05	5.32	4.84	1.50	73.60	M	dark gray sandy mud with trace gravel
4-16	-13.02	-16.07	3.05	6.10						not opened
4-17	-13.11	-14.88	0.00	1.77	2.15	0.55		1.50	S	olive-gray silty sand
4-17	-14.88	-16.16	1.77	3.05	2.58	0.83	4.50	13.00	mS	dark gray muddy sand
4-17	-16.16	-19.21	3.05	6.10						not opened
4-18	-10.30	-12.53	0.00	2.23	1.94	0.46		1.00	S	olive silty sand
4-18	-12.53	-13.96	2.23	3.66	2.32	0.53		2.50	S	olive-gray silty sand
4-18	-13.96	-14.72	3.66	4.42	3.61	1.73	1.00	37.00	mS	dark gray muddy sand
4-18	-14.72	-16.00	4.42	5.70	3.36	1.30		25.00	mS	dark gray muddy sand
4-18	-16.00	-16.40	5.70	6.10						very fine sandy silt; not tested
4-19	-12.80	-13.23	0.00	0.43	6.64	3.69		76.00	M	black sandy mud
4-19	-13.23	-14.29	0.43	1.49	3.26	1.00		20.00	mS	dark gray muddy sand
4-19	-14.29	-14.75	1.49	1.95	2.97	0.63		14.50	mS	dark gray muddy sand
4-19	-14.75	-17.80	1.95	5.00						gray gravelly sandy mud, sand increases downcore, bottom of core sandy; core sections may have been mislabeled
4-20	-11.00	-12.52	0.00	1.52	2.09	0.44		1.00	S	olive-gray silty sand
4-20	-12.52	-14.63	1.52	3.63	2.32	0.40		2.00	S	olive-gray silty sand
4-20	-14.63	-15.15	3.63	4.15	2.42	0.93	4.50	14.80	mS	dark gray muddy sand with gravel
4-20	-15.15	-15.57	4.15	4.57	2.65	0.26		5.30	S	dark gray silty sand
4-20	-15.57	-17.10	4.57	6.10						not opened
4-21	-11.77	-12.56	0.00	0.79	2.09	0.40		1.00	S	olive-gray silty sand
4-21	-12.56	-13.05	0.79	1.28	2.16	0.45		2.00	S	olive-gray silty sand

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-21	-13.05	-13.72	1.28	1.95	2.20	0.38		2.00	S	olive-gray silty sand
4-21	-13.72	-13.90	1.95	2.13	1.88	0.56	3.60	1.00	S	olive-gray silty sand with gravel
4-21	-13.90	-14.57	2.13	2.80	1.99	0.73	1.90	1.40	S	olive-gray sand with shell
4-21	-14.57	-16.34	2.80	4.57	2.41	0.59		9.00	S	dark gray silty sand with trace shell
4-21	-16.34	-17.87	4.57	6.10						not opened
4-22	-11.73	-12.10	0.00	0.37	2.21	0.40		1.00	S	olive-gray sand
4-22	-12.10	-13.89	0.37	2.16	2.10	0.44		1.00	S	olive-gray sand
4-22	-13.89	-14.29	2.16	2.56	2.50	0.57		8.50	S	dark gray silty sand with some clay
4-22	-14.29	-15.20	2.56	3.47	4.65	3.78	3.80	33.00	mS	dark gray muddy sand
4-22	-15.20	-16.00	3.47	4.27	2.93	0.97		16.00	mS	black organic silty sand
4-22	-16.00	-17.52	4.27	5.79						not opened
4-23	-10.76	-11.67	0.00	0.91	1.73	0.63			S	olive silty sand
4-23	-11.67	-13.66	0.91	2.90	1.63	0.70			S	olive silty sand
4-23	-13.66	-15.33	2.90	4.57	2.34	0.37		1.70	S	olive-gray silty sand
4-23	-15.33	-16.86	4.57	6.10						not opened
4-24	-12.31	-13.25	0.00	0.94	1.81	0.62			S	olive sand with trace shell
4-24	-13.25	-14.62	0.94	2.31	1.66	0.71	1.00		S	olive sand with trace shell
4-24	-14.62	-15.36	2.31	3.05	2.32	0.39		1.00	S	olive-gray sand with trace shell
4-24	-15.36	-18.41	3.05	6.10						not opened
4-25	-10.42	-14.29	0.00	3.87	2.04	0.41			S	olive-gray silty sand
4-25	-14.29	-16.52	3.87	6.10	2.08	0.78	2.00	5.10	S	olive-gray silty sand
4-26	-12.56	-13.99	0.00	1.43	2.23	0.59	1.20	4.00	S	olive-gray silty sand
4-26	-13.99	-14.51	1.43	1.95	2.78	1.33	3.00	16.50	mS	dark gray muddy sand with trace shell
4-26	-14.51	-15.09	1.95	2.53	3.24	2.00	5.00	21.00	gmS	mottled gray to gray-brown silty sand
4-26	-15.09	-16.34	2.53	3.78	2.31	0.64		3.50	S	gray silty sand
4-26	-16.34	-17.86	3.78	5.30						not opened

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-27	-13.17	-13.96	0.00	0.79	1.75	0.60	1.00		S	olive silty sand
4-27	-13.96	-14.27	0.79	1.10	1.50	0.66	1.10		S	olive silty sand
4-27	-14.87	-15.23	1.10	1.46	1.86	0.56		1.00	S	olive silty sand
4-27	-14.63	-16.55	1.46	3.38	2.31	0.61	1.80	7.00	S	dark gray silty sand with trace shell
4-27	-16.55	-18.08	3.38	4.91						not opened
4-28	-9.14	-13.32	0.00	4.18	2.13	0.49		1.00	S	olive sand with trace shell
4-28	-13.32	-13.71	4.18	4.57	1.90	0.74		1.05	S	olive sand with trace shell
4-28	-13.71	-14.11	4.57	4.97	2.36	0.59	1.00	5.00	S	dark olive-gray silty sand
4-28	-14.11	-14.50	4.97	5.36	3.17	0.91		17.00	mS	dark gray muddy sand
4-29	-8.96	-12.34	0.00	3.38	2.14	0.49		2.00	S	olive-gray silty sand
4-29	-12.34	-13.81	3.38	4.85	3.44	2.55	3.50	25.00	mS	dark gray silty sand with trace shell fragments
4-30	-8.75	-9.88	0.00	1.13	2.11	0.43			S	brown-gray sand
4-30	-9.88	-11.25	1.13	2.50	2.01	0.47		1.00	S	brown-gray sand
4-30	-11.25	-11.68	2.50	2.93	2.42	0.58		5.40	S	olive-gray silty sand
4-30	-11.68	-13.32	2.93	4.57	3.81	1.00		37.00	mS	dark gray silty sand
4-30	-13.32	-14.18	4.57	5.43	3.37	1.57		27.00	mS	dark gray muddy sand
4-30	-14.18	-14.85	5.43	6.10				98.30	M	dark gray silty clay
4-31	-9.57	-9.75	0.00	0.18	2.03	0.42			S	brown-gray sand
4-31	-9.75	-10.61	0.18	1.04	2.14	0.45			S	brown-gray sand
4-31	-10.61	-10.76	1.04	1.19	1.89	0.50			S	brown-gray sand
4-31	-10.76	-11.64	1.19	2.07	2.05	0.44			S	brown-gray sand
4-31	-11.64	-12.10	2.07	2.53	2.19	0.45	1.40	1.70	S	brown-gray sand with trace shell
4-31	-12.10	-12.25	2.53	2.68	-0.65	1.83	42.00	3.80	sG	brown-gray sandy gravel with shell
4-31	-12.25	-12.62	2.68	3.05				87.80	M	dark gray sandy silty clay
4-31	-12.62	-15.67	3.05	6.10						firm very dark gray mud with shells and peat, no channel sample

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-31	-13.07	-13.12	3.5	3.55				99.24	M	spot sample- 5 cm; 0.8% sand, 21.8% silt, 77.5% clay
4-31	-13.89	-13.91	4.32	4.34				99.6	M	spot sample -2 cm; 0.4% sand, 63.1% silt, 36.5% clay
4-31	-14.29	-14.35	4.72	4.78						dark brown peat, ^{14}C date- 5,570 ±70 yr. B.P. (5737 yr: 5730 1/2 life)
4-31	-14.35	-14.37	4.78	4.8				99.86	M	spot sample -2 cm; 0.1% sand, 50.0% silt, 49.8% clay
4-31	-14.77	-14.82	5.2	5.25				99.91	M	spot sample -5 cm; 0.1% sand, 32.2% silt, 67.7% clay
4-32	-8.81	-10.46	0.00	1.65	1.66	0.54			S	yellow-brown sand
4-32	-10.46	-11.19	1.65	2.38	2.64	0.56		6.00	S	dark gray silty sand
4-32	-11.19	-12.25	2.38	3.44	2.70	1.64		17.50	mS	dark gray muddy sand; not tested
4-32	-12.25	-13.08	3.44	4.27	2.34	1.90		17.50	mS	light brown silty sand
4-33	-9.05	-9.78	0.00	0.73	2.07	0.46			S	brown-gray sand
4-33	-9.78	-11.28	0.73	2.23	2.25	0.42			S	brown-gray sand
4-33	-11.28	-11.85	2.23	2.80	2.06	0.60			S	brown-gray sand
4-33	-11.85	-12.40	2.80	3.35	2.02	0.85	1.50	3.75	S	gray-brown silty sand
4-33	-12.40	-12.8	3.35	3.75	6.97	5.86		53.00	M	dark gray sandy mud with shells
4-33	-12.80	-13.62	3.75	4.57	1.75	0.69		1.40	S	light gray silty sand
4-34	-8.44	-8.99	0.00	0.55	2.05	0.49			S	brown-gray sand
4-34	-8.99	-9.96	0.55	1.52	1.99	0.38			S	brown-gray sand
4-34	-9.96	-10.88	1.52	2.44	1.67	0.47			S	brown-gray sand
4-34	-10.88	-11.82	2.44	3.38	2.03	0.63		2.20	S	olive-gray sand with trace shell
4-34	-11.82	-12.86	3.38	4.42	3.03	1.59		22.00	mS	gray silty sand
4-35	-9.66	-10.03	0.00	0.37	2.38	0.55		7.00	S	light brown-gray silty sand
4-35	-10.03	-12.71	0.37	3.05	2.38	0.46		1.00	S	olive-gray silty sand

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
4-35	-12.71	-14.78	3.05	5.12	2.56	0.41		4.00	S	gray silty sand
4-35	-14.78	-15.42	5.12	5.76	2.47	0.51	1.20	5.50	S	gray muddy sand
4-35	-15.42	-15.76	5.76	6.10	4.06	2.05		75.00	M	dark gray sandy mud
5-1	-9.14	-10.21	0.00	1.07	1.25	1.06	3.36	7.20	S	tan sand with gravel and clay-filled burrows
5-1	-10.21	-12.34	1.07	3.20						dark brown to black mud with shells, gravel and heavy minerals
5-1	-12.34	-13.44	3.20	4.30						dark olive-gray muddy sand with gravel; not tested
5-1	-13.44	-14.98	4.30	5.84						thin interbedded sand and silty clay; not tested
5-2	-7.32	-10.45	0.00	3.13	1.81	0.43			S	light tan sand with heavy minerals, and finer grain pockets
5-2	-10.45	-11.13	3.13	3.81	2.94	0.96	1.27	13.34	mS	mottled dark gray mud and sand with shell
5-2	-11.13	-12.70	3.81	5.38	2.82	0.86		11.27	mS	interbedded silty clay and sand with trace shell
5-3	-9.75	-12.72	0.00	2.97	2.01	0.62			S	tan sand with trace grav and mud
5-3	-12.72	-15.62	2.97	5.87						interbedded gray sand and dark gray sily clay; not tested
5-4	-7.01	-9.99	0.00	2.98	1.67	0.45			S	brown to tan sand, fining downcore
5-4	-9.99	-10.21	2.98	3.20	2.49	0.44		1.57	S	brown sand with finer grained layers
5-4	-10.21	-10.67	3.20	3.66	3.13	0.64		13.18	mS	dark gray to black muddy sand with trace shell
5-4	-10.67	-11.12	3.66	4.11	3.01	1.38	2.21	40.36	mS	interbedded dark gray mud, sand, and shell with peat
5-4	-11.12	-12.01	4.11	5.00	2.43	0.74	2.17	4.55	S	interbedded tan sand and dark gray mud
5-4	-12.01	-12.80	5.00	5.79	2.77	1.03		14.44	mS	mottled gray muddy sand
6-1	-8.23	-10.53	0.00	2.30	2.48	0.30			S	sand fining downcore

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS. FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
6-1	-10.53	-11.53	2.30	3.30						muddy sand with sand pockets and some shells
6-1	-11.53	-12.43	3.30	4.20						dark olive-green mud with trace shells; not tested
6-1	-12.43	-12.93	4.20	4.70						dark gray-green muddy sand with trace shells and wood fragments
6-2	-10.67	-11.27	0.00	0.60	2.89	0.94		23.22	mS	dark green muddy sand with shells; note: core location wrong
6-2	-11.27	-13.17	0.60	2.50						olive-gray silty clay with sand and trace shells; not tested
6-2	-13.17	-13.69	2.50	3.02						dark black-brown woody peat; not tested
6-2	-13.69	-14.66	3.02	3.99	2.77	0.83		11.98	mS	interbedded brown muddy sand and coarse sand
6-2	-14.66	-15.93	3.99	5.26	1.22	1.21	4.04	3.17	S	sand, silty clay fining up, wood fragments
6-3	-7.62	-7.87	0.00	0.25	1.60	0.38			S	light tan medium to coarse sand
6-3	-7.87	-8.29	0.25	0.67	1.04	0.58			S	light tan medium to coarse sand
6-3	-8.29	-8.84	0.67	1.22	1.54	0.38			S	light tan medium to coarse sand
6-3	-8.84	-9.07	1.22	1.45	1.64	0.33			S	light tan medium to coarse sand
6-3	-9.07	-10.68	1.45	3.06	1.46	0.48			S	light tan medium to coarse sand
6-3	-10.68	-11.63	3.06	4.01	1.48	0.51			S	light tan medium to coarse sand
6-3	-11.63	-11.99	4.01	4.37	1.51	0.60			S	light tan medium to coarse sand
6-3	-11.99	-9.71	4.37	2.09	1.44	0.46			S	light tan medium to coarse sand
6-4	-9.45	-10.45	0.00	1.00	1.91	0.46			S	light tan sand with shells
6-4	-10.45	-13.15	1.00	3.70	2.23	0.38			S	light tan sand with shell, fining down

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
6-4	-13.15	-14.90	3.70	5.45						mottled sand and silty clay with gravel and shells
6-4	-14.90	-15.40	5.45	5.95	2.78	0.70	1.10	9.36	mS	light gray sand with clay pockets, some wood
6-5	-10.67	-12.65	0.00	1.98	2.42	0.34		1.14	S	light tan sand with shell and some mud
6-5	-12.65	-15.65	1.98	4.98	2.20	0.52			S	light tan sand with shell and some mud
6-6	-8.53	-12.95	0.00	4.42	2.18	0.41			S	medium to fine sand
6-7	-8.53	-14.35	0.00	5.82	1.78	0.60			S	medium sand
6-8	-10.45	-11.21	0.00	0.76	5.02	4.48		64.00	M	black sandy clay
6-8	-11.21	-11.70	0.76	1.25	1.23	2.92	26.00	17.50	gmS	dark gray muddy sand with gravel
6-8	-11.70	-12.13	1.25	1.68				89.00	M	dark gray sandy clay
6-8	-12.13	-15.02	1.68	4.57	5.32	3.73		49.00	mS	dark gray sandy clay
6-8	-15.02	-16.55	4.57	6.10						not opened
6-9	-7.32	-11.89	0.00	4.57	1.44	0.51			S	light brown-gray sand with trace shell
6-9	-11.89	-13.42	4.57	6.10	1.75	0.48			S	light brown-gray sand with trace shell
6-10	-6.89	-7.20	0.00	0.31	1.57	0.55			S	light gray sand
6-10	-7.20	-9.12	0.31	2.23	1.85	0.52			S	brown-gray sand
6-10	-9.12	-10.55	2.23	3.66	1.89	0.56			S	brown-gray sand
6-10	-10.55	-12.99	3.66	6.10	2.02	0.45		1.20	S	brown-gray silty sand
6-11	-6.28	-9.33	0.00	3.05	1.68	0.66			S	light brown-gray sand
6-12	-3.05	-6.10	0.00	3.05	2.01	0.51			S	light brown-gray sand with trace shell
6-13	-8.20	-9.30	0.00	1.10	1.17	0.83		2.00	S	light brown-gray sand with shell
6-13	-9.30	-11.40	1.10	3.20	1.59	0.85		4.00	S	light brown-gray silty sand
6-14	-7.99	-9.36	0.00	1.37	1.65	0.68			S	light brown-gray sand
6-14	-9.36	-10.89	1.37	2.90	1.97	0.61			S	light brown-gray sand
6-15	-8.26	-8.66	0.00	0.40	1.97	0.48			S	light gray sand
6-15	-8.66	-11.31	0.40	3.05	2.22	0.48			S	brown-gray sand

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
6-16	-9.57	-10.82	0.00	1.25	1.85	0.48			S	light brown-gray sand
6-16	-10.82	-12.37	1.25	2.80	1.75	0.61			S	light brown-gray sand
6-16	-12.37	-13.23	2.80	3.66	2.32	0.56		2.50	S	olive-gray silty sand
7-1	-13.11	-15.81	0.00	2.70						laminated dark gray muddy sand with shells; not tested
7-1	-15.81	-16.19	2.70	3.08	2.48	0.30			S	gray medium sand
7-1	-16.19	-18.01	3.08	4.90	1.89	1.03		10.37	mS	light gray sand with mud laminae
7-1	-18.01	-18.60	4.90	5.49	2.20	0.94		10.87	mS	light gray sand with mud laminae
7-1	-18.60	-19.01	5.49	5.90	2.44	0.34		1.00	S	light gray sand with shell
7-2	-9.14	-11.14	0.00	2.00	2.37	0.39		1.09	S	gray sand with mud stringers and trace shell fragments
7-2	-11.14	-11.94	2.00	2.80						muddy sand; not tested
7-2	-11.94	-11.99	2.80	2.85						gravel; not tested
7-2	-11.99	-14.98	2.85	5.84	2.42	0.54		13.03	mS	fine sand with occasional mud laminae
7-3	-12.19	-13.53	0.00	1.34						dark olive-gray muddy sand with shell; not tested
7-3	-13.53	-14.89	1.34	2.70	3.06	0.97		42.24	mS	interbedded mud and orange sand, few shells
7-3	-14.89	-17.39	2.70	5.20	1.94	0.75		1.44	S	tan medium to coarse sand with trace silt
7-4	-13.11	-15.11	0.00	2.00	2.11	0.81	1.24	1.77	S	tan sand with silt & gravel, gastropods
7-4	-15.11	-16.01	2.00	2.90	2.87	2.09	6.68	18.66	gmS	interbedded dark gray sand and sandy mud
7-4	-16.01	-16.14	2.90	3.03	2.17	0.39		2.88	S	medium sand with mud lenses
7-4	-16.14	-17.16	3.03	4.05						mud with sand; not tested
7-4	-17.16	-17.71	4.05	4.60	1.45	1.08	4.50		S	light gray sand with gravel and shells
7-4	-17.71	-17.81	4.60	4.70						clay layer; not tested

Table VI (cont.). Textural data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
7-4	-17.81	-18.04	4.70	4.93	1.72	1.45	6.75	2.31	gS	coarse sand with shell and gravel
7-4	-18.04	-18.45	4.93	5.34	2.25	0.59		2.31	S	brown to dark gray sand with shells
8-1	-12.50	-13.50	0.00	1.00	1.57	0.94	1.29	3.78	S	tan brown sand with shells, gravel and clay pockets, coarsening downward
8-1	-13.50	-14.25	1.00	1.75	1.88	0.63			S	medium sand with mud lenses and few shells
8-1	-14.25	-14.55	1.75	2.05	2.21	1.20			S	medium sand with mud lenses and few shells
8-1	-14.55	-14.75	2.05	2.25	1.70	1.01			S	light tan sand
8-1	-14.75	-15.65	2.25	3.15	1.75	0.89			S	light tan sand
8-1	-15.65	-16.42	3.15	3.92	2.10	1.40			S	light gray to dark gray sand, mud increase with depth
8-1	-16.42	-16.91	3.92	4.41	2.54	1.10			S	light gray to dark gray sand, mud increase with depth
8-1	-16.91	-18.00	4.41	5.50	0.82	1.77	18.22	7.90	gmS	light tan sand with gravel and some silt, gravel increase with depth
8-2	-11.58	-12.47	0.00	0.89	2.14	1.06	2.45	6.34	S	light tan gray sand with clay lenses, increase clay with depth
8-2	-12.47	-13.11	0.89	1.53	1.25	1.91	16.56	6.51	gS	dark gray to black silty sand with gravel
8-2	-13.11	-13.74	1.53	2.16	3.15	0.70		11.87	mS	gray silty sand with few clay lenses
8-2	-13.74	-14.54	2.16	2.96	0.88	1.70	59.90	2.03	sG	light grayish-yellow gravelly sand with some silt
8-2	-14.54	-16.44	2.96	4.86	1.90	0.96		10.33	mS	light gray silty sand
8-2	-16.44	-16.72	4.86	5.14	0.91	1.42	10.00	5.70	gS	light gray coarse sand with gravel
8-2	-16.72	-17.25	5.14	5.67	1.73	1.09	1.00	10.04	mS	faintly laminated light gray sand

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
8-4	-11.58	-12.75	0.00	1.17						dark brown sandy mud with some peat fragments; not tested
8-4	-12.75	-14.95	1.17	3.37						interbedded sand and dark brown silty clay with peat; ^{14}C date at 2.67 meters-10,710 ±140 yrs B.P.
8-4	-14.95	-15.19	3.37	3.61	3.50	0.51		25.90	mS	light tan silty sand, some Fe staining
8-5	-13.72	-13.87	0.00	0.15						dark gray to black clay with light tan sand pockets, some shells; not tested
8-5	-13.87	-14.42	0.15	0.70	1.96	0.70	2.93	2.88	S	light gray to white sand with silty clay and gravel, no shells
8-5	-14.42	-15.62	0.70	1.90	-0.75	1.40	47.55	1.04	sG	sandy gravel with trace of silt
8-5	-15.62	-16.95	1.90	3.23	2.28	0.95	1.49	2.07	S	light gray to white sand with trace silt
8-5	-16.95	-17.72	3.23	4.00	3.25	0.14	1.07	6.10	S	dark gray, very well sorted, sand with silt
8-5	-17.72	-18.52	4.00	4.80	0.03	2.59	47.00	4.67	sG	gray to light gray gravelly sand with some silt
8-5	-18.52	-19.92	4.80	6.20	3.04	0.86		20.29	mS	light gray muddy sand
9-1	-10.97	-16.76	0.00	5.79	1.17	0.43				light tan medium to coarse sand with heavy minerals and shells
9-2	-8.23	-13.02	0.00	4.79	2.21	0.34				light gray to tan mottled sand
9-3	-8.23	-12.22	0.00	3.99	1.90	0.32				light tan sand with trace shell and gravel
9-4	-10.79	-11.86	0.00	1.07	0.28	1.48	20.00		gS	light brown-gray gravelly sand with shell fragments
9-4	-11.86	-14.90	1.07	4.11	1.13	0.95	5.00		gS	light brown-gray gravelly sand with shell fragments
9-5	-10.70	-12.99	0.00	2.29	1.19	0.49			S	light brown sand with shell fragments

Table VI (cont.). Textual data and visual descriptions of vibracore sediment samples.

CORE	SAMPLE DEPTH INTERVALS (METERS)				TEXTURAL PARAMETERS				CLASS FOLK (1954)	BRIEF LITHOLOGIC DESCRIPTIONS AND COMMENTS
	NGVD		DEPTH IN CORE		MEAN (PHI)	SORTING (PHI)	% GRAV	% MUD		
	UPPER	LOWER	UPPER	LOWER						
9-5	-12.99	-13.56	2.29	2.86	0.80	0.79	2.80		S	light brown sand with shell fragments
9-5	-13.56	-14.66	2.86	3.96	1.42	0.84	1.00		S	light brown-gray sand
9-5	-14.66	-15.00	3.96	4.30	1.63	0.80			S	light brown-gray sand
9-5	-15.00	-15.88	4.30	5.18	2.17	0.72		2.00	S	olive-gray sand with trace silt
9-6	-10.30	-12.95	0.00	2.65	1.77	0.41		1.00	S	light brown-gray sand
9-6	-12.95	-14.48	2.65	4.18	1.75	0.41			S	brown-gray sand
9-7	-9.36	-10.37	0.00	1.01	1.48	0.50			S	light brown-gray sand with trace shell
9-7	-10.37	-13.54	1.01	4.18	1.50	0.34			S	light brown-gray sand with trace shell
9-8	-10.58	-13.93	0.00	3.35	1.42	0.42			S	light yellowish-brown sand
9-9	-10.64	-12.16	0.00	1.52	1.95	0.46			S	brown-gray sand
9-9	-12.16	-13.14	1.52	2.50	1.91	0.56			S	brown-gray sand
9-9	-13.14	-13.69	2.50	3.05	2.14	0.51	1.00	3.30	S	gray-brown silty sand
9-9	-13.69	-14.66	3.05	4.02	2.13	0.41			S	light gray sand
9-9	-14.66	-15.43	4.02	4.79	2.11	0.41		1.00	S	light brown-gray sand
9-9	-15.43	-16.74	4.79	6.10	2.26	0.47		2.00	S	gray-brown silty sand
9-10	-9.48	-10.85	0.00	1.37	1.74	0.42			S	light gray sand
9-10	-10.85	-11.77	1.37	2.29	1.75	0.61			S	light brown-gray sand
9-10	-11.77	-12.99	2.29	3.51	2.28	0.44			S	light brown-gray sand
9-10	-12.99	-13.44	3.51	3.96	2.23	0.41		1.10	S	light brown-gray silty sand

Table VII. Summary of radiocarbon data for this study.

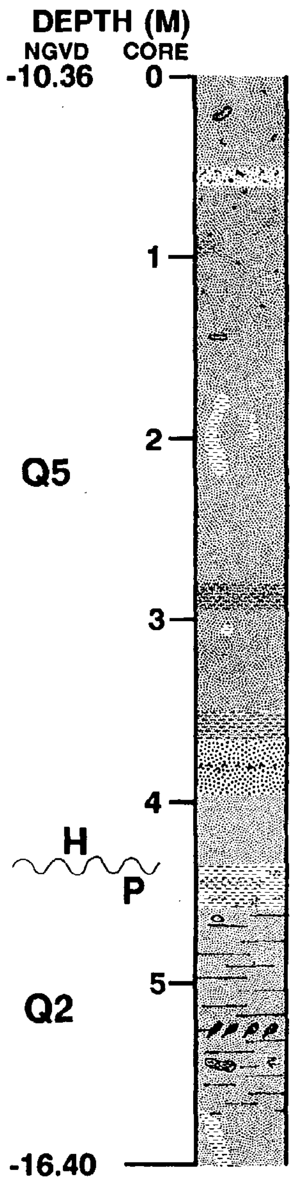
Core	Material	Depth (m) (NGVD)	$_{14}C$ Date 5568-yr ½ life yr B.P. + 1σ
1-3	peat[1]	- 7.86	31,190 ± 1330
3-12	organic-rich mud[1]	-15.00	32,240 ± 1520
4-31	peat[2]	-14.32	5,570 ± 70
8-3 (in Del., see Underwood and Anders, 1987)	peat[1]	-14.90	29,550 ± 1450
8-4	peat clasts[1]	-14.25 to -14.44	10,710 ± 140

[1] Sample taken by CERC and analyzed by Univ. of Texas.
[2] Sample taken by MGS an analyzed by Beta Analytical, Inc.

Appendix II

Lithologic logs for selected vibracores re-examined for this study.

CORE 2-8



MEAN	SORTING
Phi (ϕ) Units	
1.72	0.91
2.49	1.02
2.43	0.40

CORE 2-8

Unit 1
SAND:

0-350 cm
Tan to gray medium sand, with some gravel, fining downcore, muddy sand-filled burrows and fine laminae of silty sand toward bottom, occasional shells including *Ensis*, *Crassostrea*, and *Noetia ponderosa* (one valve).

350-366 cm
Finely laminated clayey silt and fine sand.

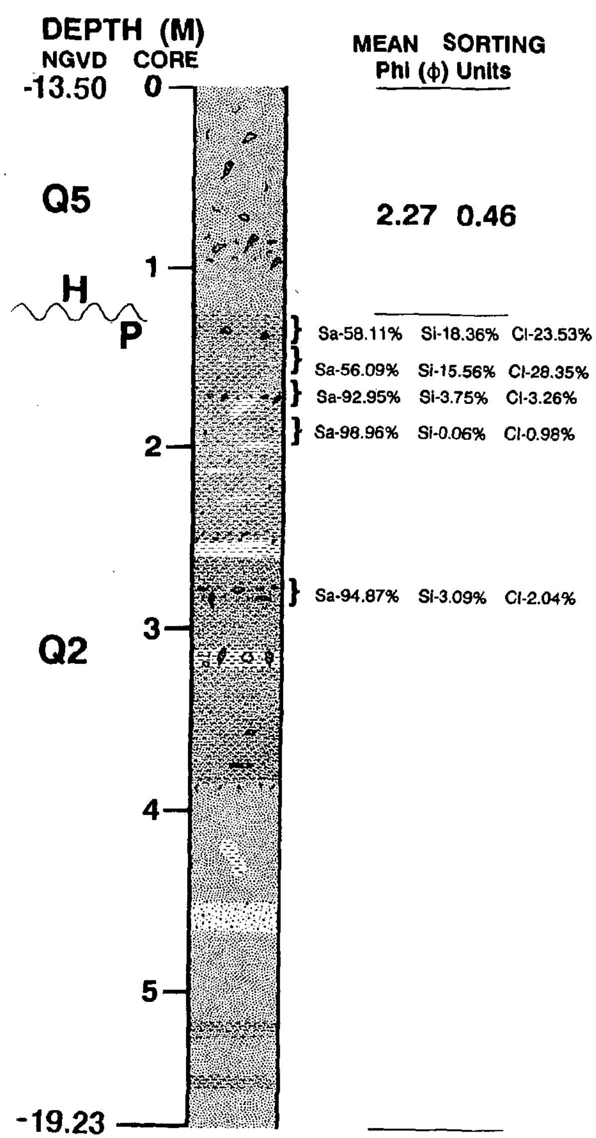
366-434 cm
Reddish-brown (iron-stained) coarse sand, fining down to gray fine sand, finely laminated; layer of shell fragments at 380-390 including barnacle shells (*Balanus*).

Unit 2
MUD:

434-560 cm
Gray-green dewatered mud with sand stringers and sand pockets; sand increases with depth; shells common including *Nassarius* and *Macoma*; peat with some wood fragments toward bottom of unit.

560-604 cm
Tan fine sand with muddy sand-filled burrows.

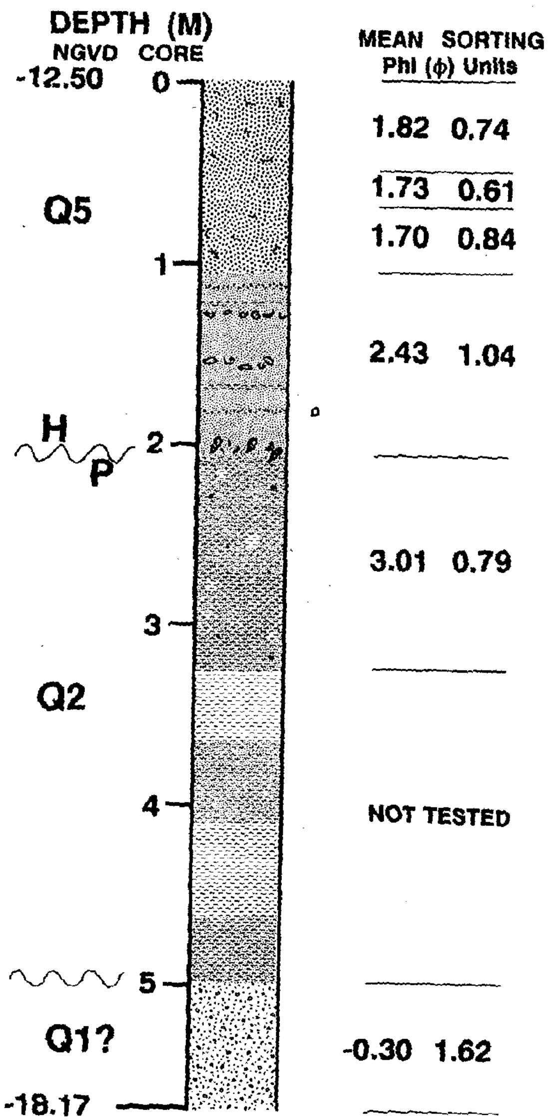
CORE 2-27



CORE 2-27

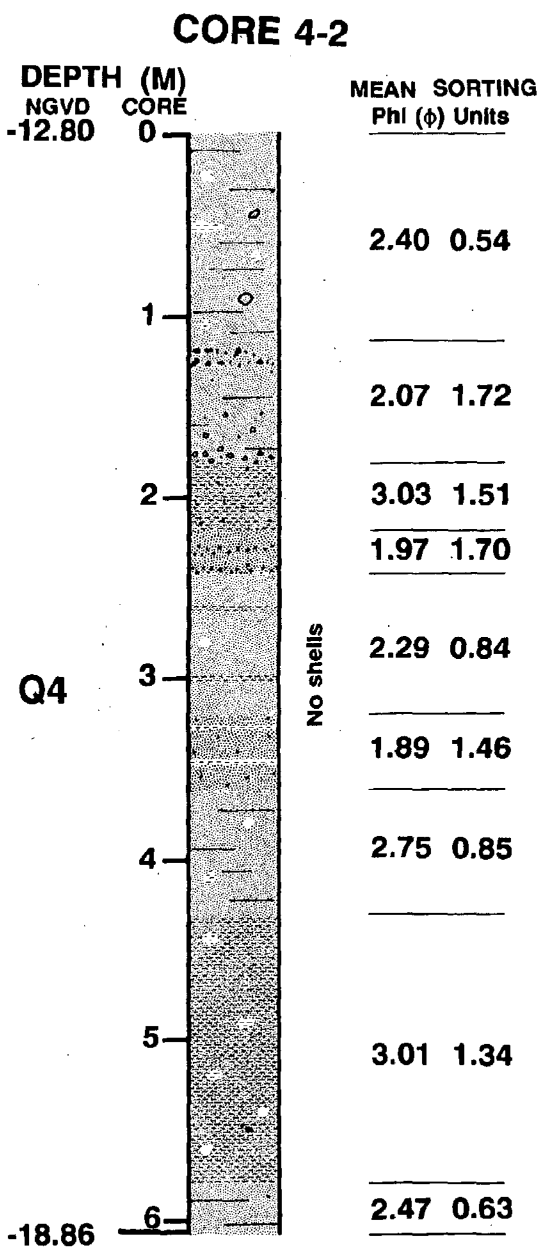
Unit 1 SAND:	0-124 cm Dark gray fine sand, coarsening downcore to medium fine sand, shells and shell fragments common: *Spisula, Macoma, Mulinia, Busycon* (juvenile), *Polinices, Lunatia.*
Unit 2 MUD:	124-152 cm Dark olive-gray (5Y3/2) interbedded silty clay and sandy mud, occasional shell fragments.
	152-380 *cm* Dark olive-gray (5Y3/2) muddy fine sand, silt increases downcore; mud pockets and stringers, occasional well-rounded gravel; shells common, shell layers at 170-172, 245-255, 286-292, and 310-320 cm: include *Nassarius, Ensis, Macoma.*
Unit 3 SAND:	380-540 cm Mottled medium light gray (N5) to medium gray (N6) medium to fine sand, occasional gravel and mud pockets, no shells except at very top of unit; thin muddy sand laminae at bottom of unit.
	540-573 cm Yellow-gray (5Y7/2) fine sand, well sorted.

CORE 3-12



CORE 3-12

Unit 1 SAND:	0-105 cm	Mottled tan to brown to dark gray medium sand with occasional shell fragments.
	105-206 cm	Gray to dark gray fine sand with occasional laminae of muddy sand and gravel, distinct shelly layers at 120-125, 157-162, 195-205, abundant *Spisula*, with occasional *Nassarius*.
Unit 2 *MUD*:	206-497 cm	Mottled gray to dark gray muddy sand and dark gray dewatered clay with occasional *gravel*, *fine* laminae toward bottom.
Unit 3 SAND:	497-567 cm	*Light gray* silty coarse sand and gravel.



CORE 4-2

Unit 1
SAND:

0-114 cm
Gray to dark gray-black silty fine sand with occasional coarse sand layers and clay pockets, overall fining down core, *Spisula* common.

114-183 cm
Muddy medium to fine sand with gravel; gravel increases downcore; shell layers at 118-119 and 123-125; *Crepidula*, *Ensis*, and *Spisula*.

Unit 2
SAND:

183-219 cm
Dark gray silty fine sand.

219-320 cm
White to tan to gray fine to medium sand, coarsening down core; fine grained heavy minerals present; occasional clay laminae.

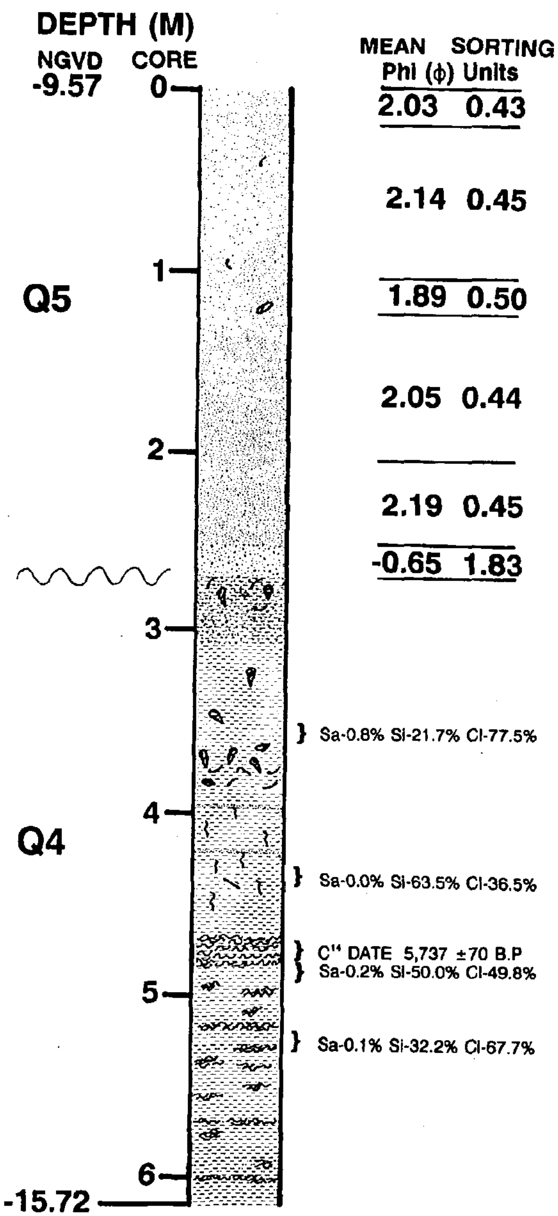
320-361 cm
Light gray to tan, medium to fine sand with gravel and muddy sand laminae, heavy minerals present.

Unit 3
MUD:

361-579 cm
Mottled (highly bioturbated) dark gray to gray silty fine sand and muddy sand with numerous clay pockets, no shells.

579-606 cm
Dark brown silty fine sand.

CORE 4-31



CORE 4-31

Unit1 SAND:

0-268 cm
Tan to light brown-gray medium sand with faint laminae (heavy minerals); occasional shell fragments, muddy sand clast; increase in gravel coarse sand at 250 cm with some iron staining.

268-305 cm
Abrupt change to gray-brown gravelly sandy mud, micaceous, gravel gradually decreases downcore.

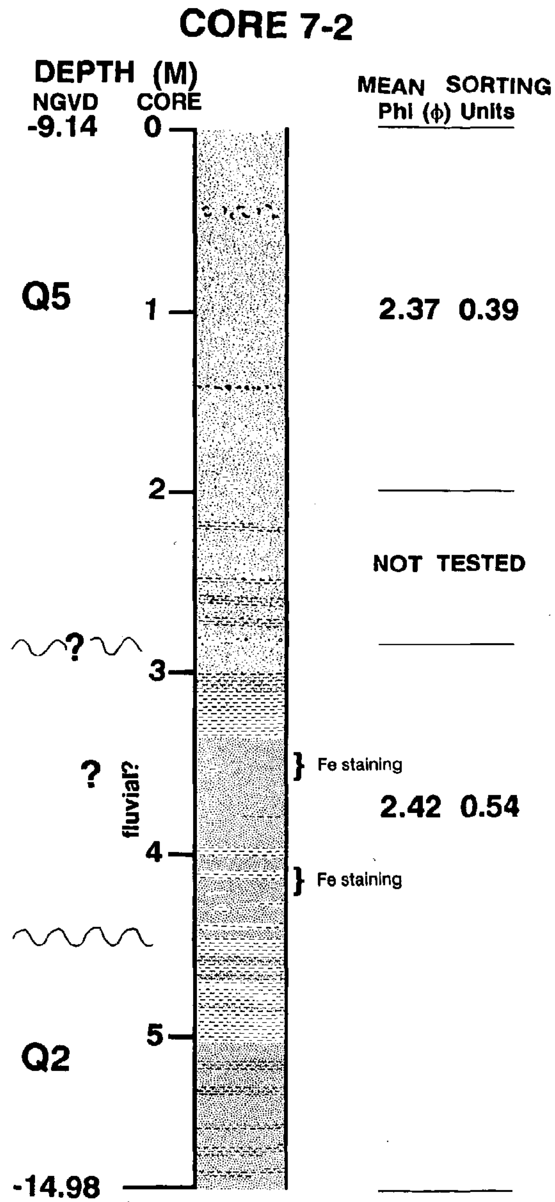
Unit 2 MUD:

305-387 cm
Dark gray clayey silt, shells and shell fragments, scattered whole gastropod shells (*Nassarius*): shell layer at 375-387 cm: *Littorina*, *Crepidula*, *Modiolus*.

387-463 cm
Dark gray clayey silt interbedded with thin laminae of sandy mud, vertical inclusion of peat like material, rhizomes/roots remnants, peat layer at bottom of unit; no shells.

463-480 cm
Dark brown peat layer w/some silty mud; ^{14}C date: 5570+/_ 70 yrs.

480-615 cm
Interbedded, dark gray, dewatered, silty mud with some peat, peat decreases with depth.



CORE 7-2

Unit 1 SAND:

0-200 cm
Gray fine sand with mud stringers and occasional gravel; some whole shells, mainly juvenile gastropods, and very small shell fragments.

200-303 cm
Gray muddy sand with gravel; distinct well-rounded gravel layer at 270-290 cm.

Unit 2 MUD:

303-445 cm
Finely interbedded (1-5 cm) gray dewatered mud and fine sand with occasional clay pockets, no shells, distinct iron-staining at 340-360 cm. and 410-445 cm.

445-584 cm
Dark green clay interbedded with sandy mud, occasional clay pocket, no shells.

Plate 1. Interpreted seismic profile lines COE 56, 60, 62, and 63 (ORE 3.5 kHz) collected on shoals 4 & 5). Acoustic units interpreted as Q4 deposits are indicated by gray shading.

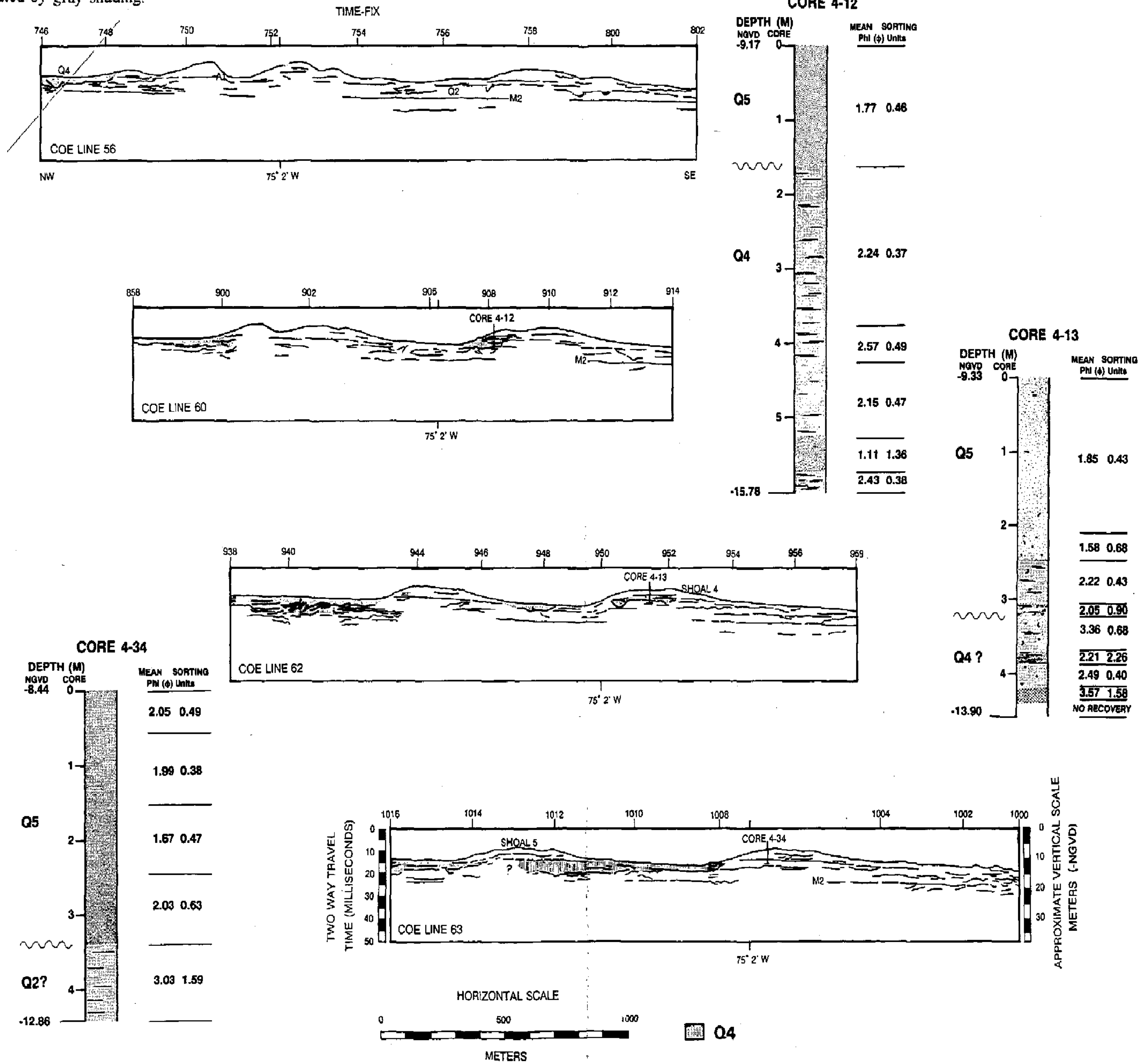


Plate 2. Interpreted seismic profile lines COE 64, 65, 66, and 67 (ORE 3.5 kHz) collected on shoals 4 & 5). Acoustic units interpreted as Q4 deposits are indicated by gray shading.

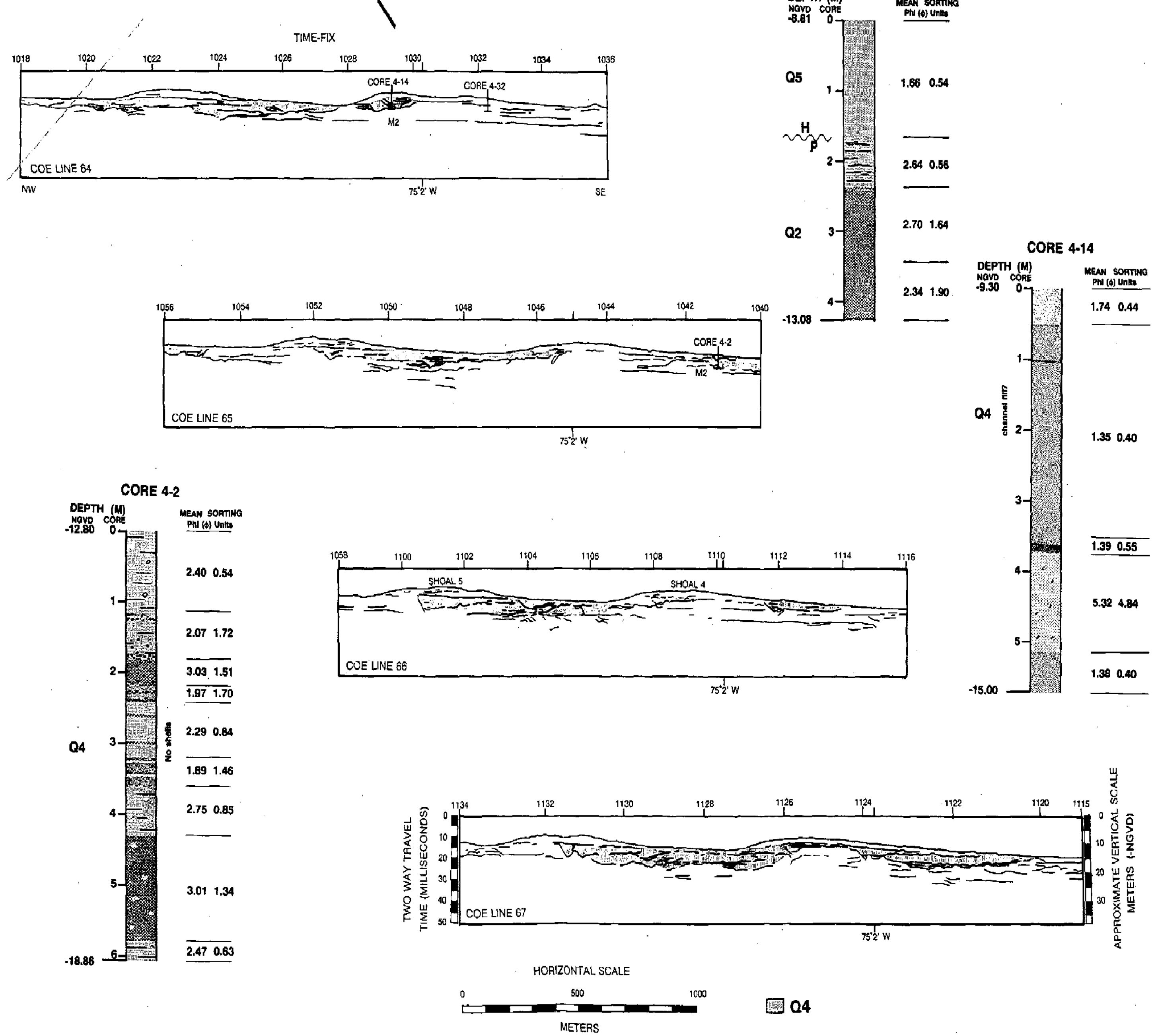


Plate 3. Interpreted seismic profile lines COE 69, 70, 71, and 72 (ORE 3.5 kHz) collected on shoals 4 & 5). Acoustic units interpreted as Q4 deposits are indicated by gray shading.

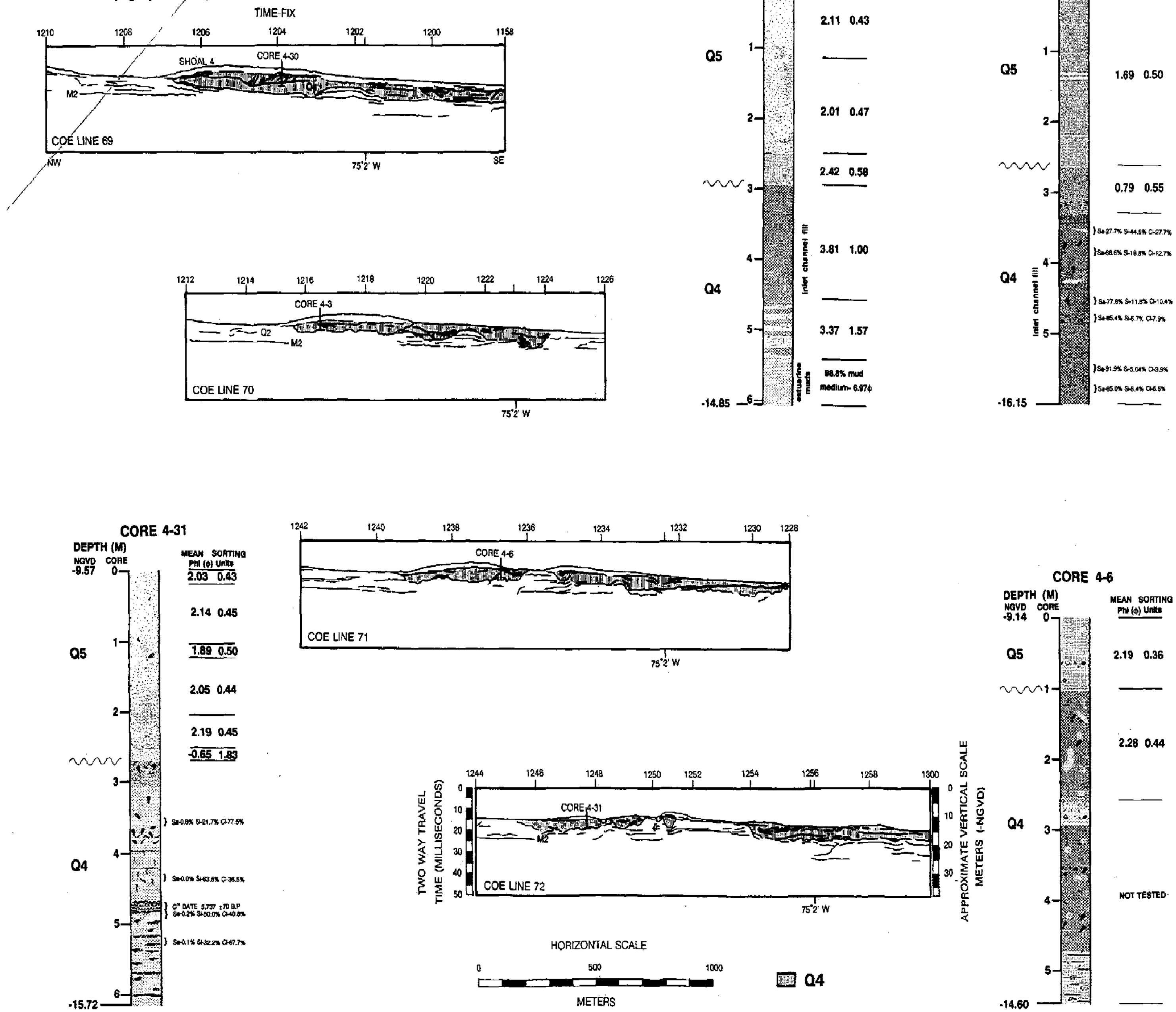


Plate 4. Reconstruction of early Holocene drainage on inner shelf off Ocean City, Maryland. Shown are inferred relationships between paleochannels mapped by Field (1976, 1979), Toscano *et al.* (1989) and this study.